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SOME BYGONE OPERATIONS IN SURGERY.

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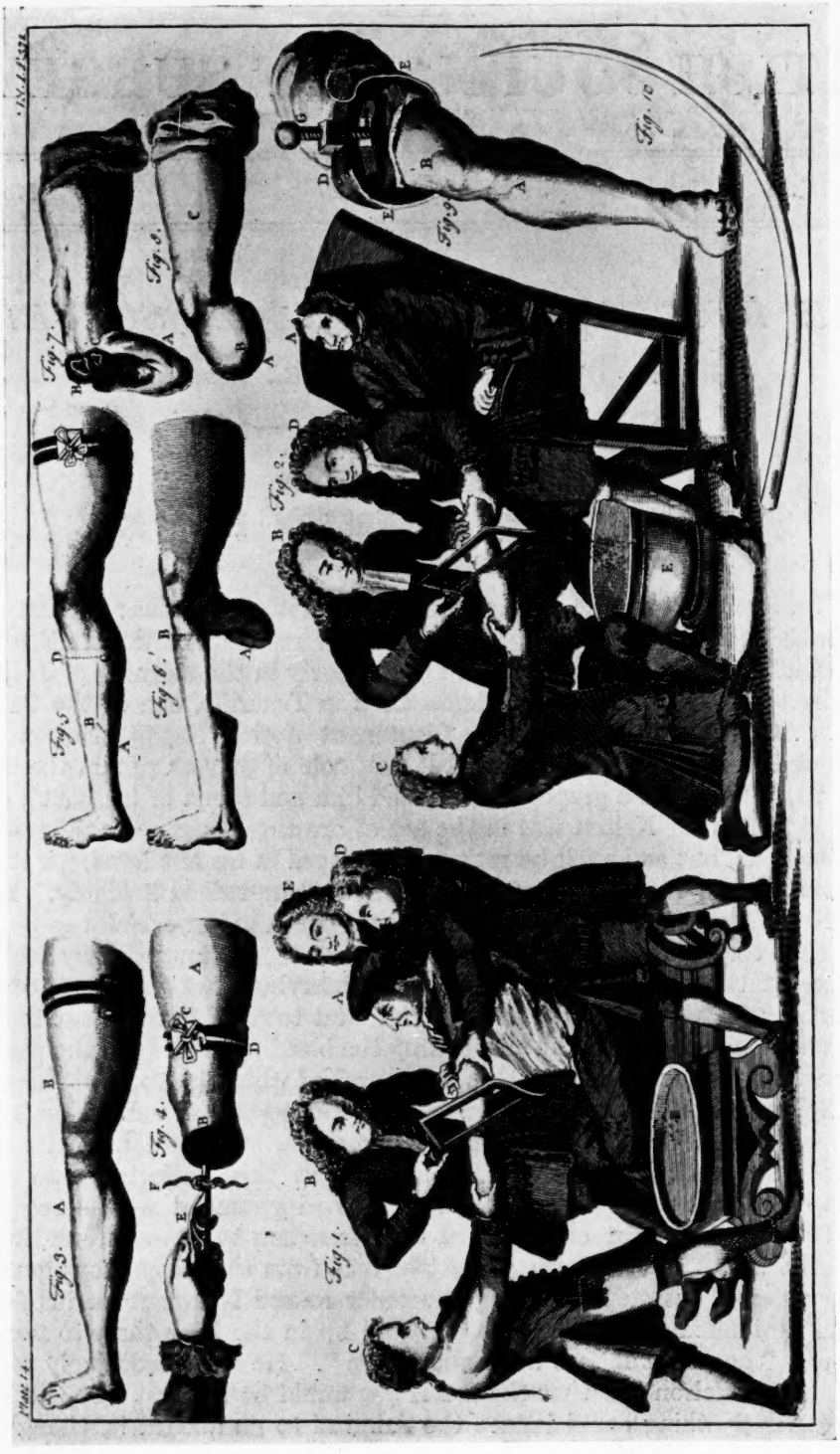
VII. AMPUTATION: THE OPERATION ON NELSON IN 1797.

(Concluded.)

EVERYONE knows that the pictures and portraits of Nelson represent him with his right sleeve empty and folded, but few remember the details of the injury which led to the amputation of his arm early in the morning of July 27, 1797, directly after the attack on Santa Cruz in Teneriffe, one of the Canary Islands. Attended by his stepson, Lieutenant Josiah Nesbit, Nelson was being rowed from the *Sea Horse* towards the mole of Santa Cruz on the night of July 24, 1797, when a grapeshot wounded him and seven of his boat's crew in their right arms. Nelson was in the act of drawing his sword and stepping out of the boat, but as he fell he grasped the sword in his left hand, for it had been given him by his uncle Maurice Suckling and he valued it highly. Lieutenant Nesbit, who was just behind him, heard the Admiral exclaim as he fell, "I am shot through the arm, I am a dead man." He immediately laid his stepfather at the bottom of the boat, and observing that the sight of the blood coming from the arm was making him faint took off his own hat to hide it from view. He then held the arm to stop the bleeding, examined the wound, and bound up the arm tightly with a handkerchief which he took off his own neck. Nelson said afterwards that he owed his life to this action. Nesbit was assisted by Lovel, one of the admiral's bargemen, who tore his shirt into strips to make a sling. Five other seamen were then collected, and with their help the boat was pushed afloat, for it had grounded with a receding tide. Nesbit took an oar and ordered the steersman to run close under the guns of the battery so that they might be safe from the tremendous gunfire.

The voice of his stepson giving the order roused Nelson from his faintness, and he immediately desired to be lifted up in the boat that, to use his own words, "he might look a little about him". He was accordingly raised by Nesbit, and Nelson saw that the *Sea Horse* would be the first ship the boat would reach. Nothing could induce the Admiral to go aboard it, though he was told that it might risk his life if they continued to row to another ship.



AMPUTATION AT THE CLOSE OF THE EIGHTEENTH CENTURY.
From the English translation of Laurence Heister's *General System of Surgery*, 1778.

"Then I will die," he said, "for I would rather suffer death than alarm Mrs. Fremantle by her seeing me in this state when I can give her no tidings whatever of her husband." (Captain Fremantle was in command of the *Sea Horse* and Nelson had only recently attended his wedding.) The boat was accordingly rowed to the *Theseus*, where notwithstanding the increased pain and weakness Nelson peremptorily refused all assistance in getting up the ship's side, saying "Let me alone. I have yet my legs left and one arm. Tell the surgeon to make haste and get his instruments. I know I must lose my right arm, and the sooner it is off the better." Mr. Hoste (afterwards Captain Sir Henry Hoste), one of the midshipmen on the *Theseus*, wrote to his father: "At two o'clock in the morning Admiral Nelson returned on board, being dreadfully wounded in the right arm with a grapeshot. I leave you to judge of my situation when I beheld our boat approach with him who I may say has been a second father to me, his right arm dangling by his side, whilst with the other he helped himself to jump up the ship's side and, with a spirit which astonished everyone told the surgeon to get his instruments ready for he knew he must lose his arm and that the sooner it was off the better. He underwent the amputation with the same firmness and courage that always marks his character."

Whilst he waited for the necessary arrangements to be made for the operation Nelson busied himself with the relief party which he sent to rescue the survivors from the *Fox*, and then descended into the cockpit. By this time he was somewhat collapsed, for he said afterwards that the feeling of cold was severe, and he subsequently ordered that portable stoves should be supplied to the cockpit in every ship under his command.

The surgeon to the *Theseus* was Thomas Eshelby, who must have been quite a young man, for the records of the Surgeons' Company show that he was examined on April 7, 1791, and was found fit to be a third mate on a third-rate. He was examined again on Sept. 4, 1794, and was then reported as qualified for surgeon to a fourth-rate. He joined the *Theseus* by warrant on May 27, 1797, when he received a Bounty of £20. He took the place of Samuel Hardy, qualified to act as surgeon to a first-rate, who had been discharged to H.M.S. *Captain* on May 26, 1797. There is no mention of a second surgeon, but the Muster Roll contains an entry, "George Henderson 3rd. mate of Alloa, Scotland, joined by warrant 13th. March 1797 drowned at the storming of Santa Cruz." Eshelby, therefore, was short-handed at the time.

The amputation was performed by the circular method at the seat of election—that is to say, just below the insertion of the deltoid and at the point where the median nerve crosses the brachial artery. A good deal of force must have been used in retracting the soft parts, for it was realized later that the stump was unusually short. The subsequent progress appears in the extracts from the Medical Journal of H.M.S. *Theseus* reproduced on the next page.

Silk ligatures were used and the second ligature had included the median nerve as well as the artery. It proved to be a source of much trouble and pain, and did not come away until Dec. 4, 1797, when the sinus healed quickly. The pain which was accompanied by twitching of the stump was

Public Record Office
Adm. Med. Journals
128/2.

Medical Journal of His Majesty's Ship the *THESEUS* . . . from the 26th May 1797 to the 18th August 1797 during which time the said Ship has been employed off Cadiz &c. &c. &c.

P. 7 May 27th 1797. [Captain R. W. Miller Surgeon Thomas Eshelby]

Men's Names, Ages, and Qualities	When and Where put on the Sick List	Statement of the Case when put on the List	Symptoms and Treatment while under Cure	When discharged to Duty, Died, or sent to the Hospital	Remarks
Admiral Nelson P. 9	25 July	Compound fracture of the right Arm by a musket ball passing thro' a little above the Elbow; an Artery divided; the Arm was immediately Amputated, and the following give [*sic*] him ℞ Opii gr. ij. f. Pil. statim s. Rep. Pil. Opii gr j—— Rep. Pil. Opii gr ij hora s.s.			
Admiral Nelson P. 10	Page 7th	Amputated Arm	Rested pretty well and quite easy. ℞ Mist Salin. ℥ij ter in die Repr Pil opii hora s.s.		Tea, Soup & Sago, Lemonade & Tamarind Drink——
Admiral Nelson P. 11	Page 7th	Amputated Arm	Had a middling Night. No fever. Repr Pil Opii hora somni s.		
Admiral Nelson P. 12	Page 7th	Amputd Arm	Dressed the stump, look'd well. ℞ Decoct. Cinchon. ℥iss ter in die Rep Pil Opii h.s. s.		
Admiral Nelson P. 14	Page 7th	Amputated Arm	Pretty easy. had no stool since the Operation. gave the follwg ℞ Infus. Senæ ℥ij Pulv. Jalap. Sp: Lavd co. ℥js mane sumd Rep Pil. Opii hora somni s.		
Admi Nelson P. 15	Page 7th	Amputated	The Cathartic operated well. pretty easy. Rep. Pil Opii h s. s. Rep. Decoct. Cinchon.		
Admi Nelson P. 16	Page 7th	Amputated Arm	One of the Ligatures came away. looks well. Rep. med. ut heri		
Admiral Nelson	Page 7th	Amputated Arm	Continued getting well very fast stump look'd well. no bad symptom whatever occurred. he continued the use of the Cortex. and a gentle opening Draught occasionally.	Discharded* on board the *Seahorse* 20th August * [*sic*]	The sore reduced to the size of a shilling, in perfect good health one of the Ligatures not come away.

so severe that Nelson was given opium from time to time for its relief. Elliot, afterwards Lord Minto, who saw him before the ligature came away, reports that he found Nelson looking better and fresher than he ever remembered him, although the continued pain prevented sleep. He was already impatient to go to sea again, and chafed under the delay of healing, concerning the duration of which the surgeons could give him no assurance. The ligature must be left to slough away, they said, for it was two inches up the wound, and if, attempting to cut it, the artery should be cut, another amputation higher up would be necessary, which would not be easy, for the stump was already very short. As soon as the ligature came away, Nelson, who had been lodging in Bond Street, sent a notice to the Rector of St. George's, Hanover Square, saying, "An officer desires to return thanks to Almighty God for his perfect recovery from a severe wound, and also for many mercies bestowed upon him."

The log of the *Theseus*, which is signed by Captain Ralph Willett Miller, merely says, "At ½ past 10 p.m. the seamen and marines left the ship under command of Rear Admiral Nelson. At ½ past 2 a.m. began a heavy cannonading in the Town. At ½ past 3 Admiral Nelson returned on board (being wounded in his right arm which occasioned it to be cut off.)"

I am indebted to the Secretary of the Admiralty and to Mr. Warren R. Dawson for several references. Miss E. H. Fairbrother kindly made the extract from the Medical Journal of H.M.S. *Theseus* which is printed on page 354. The document is preserved in the Public Record Office, Chancery Lane. The illustration taken from the 1778 English translation of Laurence Heister's *General System of Surgery* shows the method of amputation in use at the time of Nelson's operation.

CONGENITAL LYMPHANGIECTATIC FIBROUS HYPERTROPHY (ELEPHANTIASIS CONGENITA FIBROSA LYMPHANGIECTATICA).

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Under the heading of 'congenital elephantiasis' there have been described a very interesting series of congenital overgrowths. These are of considerable rarity, and it has been thought worth while to place on record a detailed report of such a case.

The term 'elephantiasis' has purposely been replaced by the word 'hypertrophy' in the title of this paper. 'Elephantiasis' has been used indiscriminately with reference to the filarial and non-filarial forms of enlargement, leprosy, congenital hypertrophy, congenital œdema, and to cases of local gigantism. The term 'elephantiasis' apparently originated as a soldier's slang expression in the Roman army during the Libyan campaign, but whether it referred to filarial elephantiasis, leprosy, or beri-beri will probably never be decided. However hallowed the expression may be by the lapse of time and by its passage through the pages of countless text-books, it is clearly neither descriptive nor associated with any scientific meaning. It should, therefore, be set aside for the delectation of the laity so far as the class of case dealt with in this paper is concerned.

CASE REPORT.

A male child, age 10 months, was admitted to the Royal Edinburgh Hospital for Sick Children in November, 1928, and the following history was obtained :—

History.—Fourteen days before the infant was born the mother had a severe fall. The child was one of binovular twins, and the labour was premature by one month. Immediately after birth the child was noticed to have a swelling in the neighbourhood of the right wrist, and this was attributed by the accoucheur to an intra-uterine fracture of the distal extremity of the radius. Since birth, however, the right wrist steadily, though very slowly, increased in size, and the thickening extended from the wrist into the palm of the hand. The family history proved negative in so far as it was accessible.

On Examination.—On examining the affected extremity a hard nodular swelling appeared to surround the distal end of the right radius. The skin was firmly bound to the underlying tumour, but the whole mass possessed a restricted degree of mobility upon the subjacent radius. The swelling extended into the palm of the hand, several hard nodules being present in the thenar and hypothenar eminences. Even at this stage the hand seemed to be completely functionless, and suggested a deformed hand which had been carved from a block of wood.

Radiographic examination showed no obvious erosion or enlargement of the radius, though the cortical bone on the lateral aspect of the distal half of the right radius was definitely sclerosed as compared with that on the left. The Wassermann reaction was negative.

On Nov. 13 a biopsy was performed. A portion of tissue was removed through an incision on the lateral aspect of the wrist. The tumour cut with the 'creaking' sensation typical of a hard fibrous structure, and the intimate connection between

the tumour and the overlying skin was very evident. A further small piece of tissue was removed from the hypothenar eminence for examination.

PATHOLOGICAL REPORT.—Dr. Agnes MacGregor, Pathologist to the Royal Edinburgh Hospital for Sick Children, reported upon these fragments of tissue as follows :—

"All parts of the mass examined are composed of dense mature fibrous tissue. When muscle is present at the edge of the mass, it is undergoing fibrous replacement, muscle fibres being separated by fibrous tissue and showing various stages of atrophy. In some such places the fibrous tissue is rather more cellular, but even then very well formed. The histological appearances are those of scar tissue rather than of neoplastic growth. If the condition is a tumour, the histological characters give no ground whatever for supposing it to be malignant."

PROGRESS.—A short time later the child was demonstrated before a clinical meeting of the Edinburgh Medico-Chirurgical Society, and the consensus of opinion among those present was that, though it was a simple non-neoplastic condition at the moment, amputation was advisable in view of the likelihood of the occurrence of an ultimate fibrosar-comatous change.

The child was kept under observation for four months, and during this period the tumour gradually increased in size. The palm of the hand became more diffusely involved, the metacarpals being pushed apart and giving a trident-like appearance to the extremity. In addition an appreciable degree of extension took place proximally along the lateral aspect of the shaft of the radius.

FIG. 269.—Drawing of the forearm and hand immediately after disarticulation. This shows the palmar overgrowth very well, though the portion surrounding the radius is not so clearly brought out.

At this time (March, 1929) it was decided to amputate. The reasons for coming to this conclusion were the steady increase in size of the tumour with its evident infiltrating character, the loss of prehensile power, and the ever-present fear of a malignant change, as frequently occurs in cases of diffuse angiomatous hypertrophy of a limb.

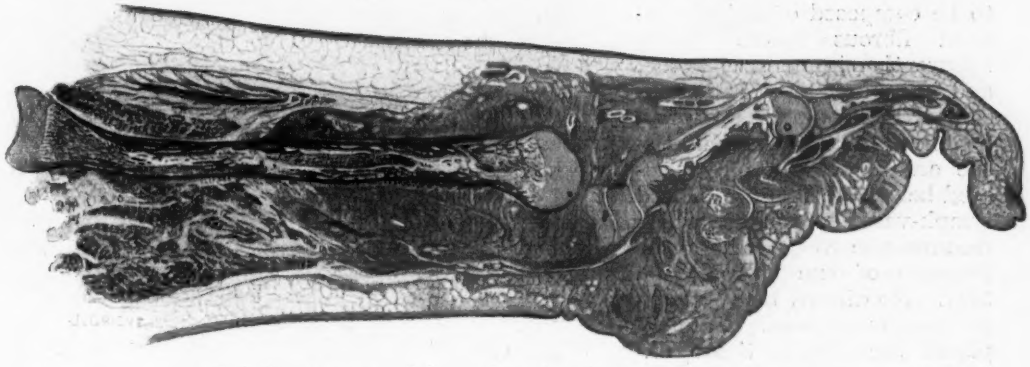

FIG. 270.—Longitudinal whole section of forearm and hand.

OPERATION.—On March 14, therefore, the forearm and hand were removed by disarticulation through the elbow-joint. The child has since remained well (May, 1931). *Fig.* 269 shows the appearance of the hand at the time of removal.

FIG. 271.—Section to show the fibrous structure of the tissue with valved dilated lymph-vascular spaces.

HISTOLOGICAL EXAMINATION.—Colonel Harvey, of the Laboratory, of the Royal College of Physicians of Edinburgh, undertook the complete histological demonstration of the specimen. The forearm and hand were frozen and sawn through in the long axis of the radius. A thin sheet of tissue was then sawn off one face of the specimen and decalcified. Large sections were taken from the whole surface and fitted together on mounting to show the whole length on one slide.

Fig. 270 is a painting of this preparation as a whole section, done for me by Mr. J. Grieve. Inspection of the section shows that the mass of fibrous tissue has surrounded the distal half of the radius and fills the palm of the hand. The muscles of the forearm appear to be normal, but their tendons become incorporated in the fibrous mass at the wrist. Closer inspection shows the undisturbed fibres of the pronator quadratus muscle cut across at their insertion into the anterior aspect of the radius. In contrast to this, however, the small muscles of the hand have disappeared, and microscopical examination showed only the remains of a few fibres undergoing an apparent pressure atrophy.

More detailed microscopic examination shows the tumour to be composed of fully developed fibrous tissue. It is apparently simple scar tissue, and in no area does it demonstrate any neoplastic property. Scattered throughout this tissue and more especially situated below the skin are dilated lymph-vascular spaces which demonstrate very clearly the presence of fine valves (*Fig.* 271). No dilated blood-vascular spaces were seen. In many places the fibrous tissue extends up to the deeper layers of the dermis and is accompanied by a considerable degree of hyperkeratosis of the overlying stratum corneum (*Fig.* 272).

FIG. 272.—Section to show hyperkeratinization of the skin overlying the fibrous area.

From the history and the clinical and histological examination, this appears to be a case of congenital fibrous lymphangiectatic hypertrophy affecting the fibrous connective tissues of the right wrist and hand.

DISCUSSION.

I have found only one description of an apparently similar case. Spinner[1] describes a similar picture in which the congenital fibrous hypertrophy affected the right leg below the knee. Dilated lymph-vascular spaces were also present in large numbers, many being of macroscopic size. In his case, however, the condition was associated with an increase of growth in length of the bones of the leg—that is to say, a true gigantism.

Aschoff[2] divides congenital hypertrophies into :—

1. Local gigantism, in which there is merely an increase in bulk of a limb, all the tissues being equally affected, and which is unassociated with 'tumour' formation. Such a case affecting the right leg is shown in *Fig.* 273. Even in cases such as this, however, it is usual to see definite dilatation of the subcutaneous veins over a part of the overgrown limb. In the case figured definite venous dilatation was present in the thigh.

2. Congenital 'elephantiasis', which is not a uniform enlargement of all constituent parts of a limb with conservation of the normal proportions, but an overgrowth affecting only separate tissues and often leading to dreadful deformities.

According to the tissue involved Aschoff subdivides these enlargements into elephantiasis fibrosa, lipomatosa, angiomatosa, lymphangiomatosa, and neuromatosa. He also draws attention to the frequent occurrence of hyperkeratosis and warty proliferation of the skin overlying the hypertrophied area. Further, and most wisely, he safeguards this classification by stating that 'elephantiasis' and 'true local gigantism' may co-exist, just as we have seen them to do in Spinner's case.

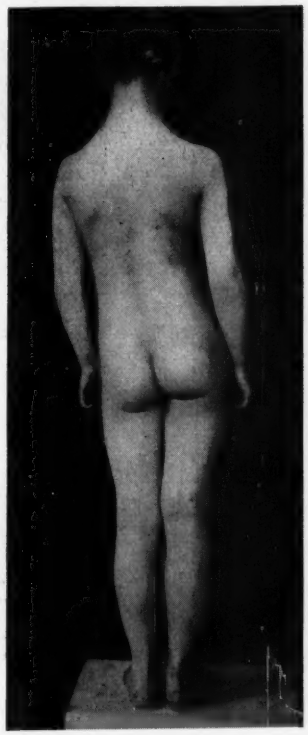

Fig. 273.—Female, age 5½. Shows local gigantism of the right leg. Considerable venous dilatation was present in this limb, but is not obvious in the photograph.

It becomes quite obvious that hard-and-fast methods of classification cannot be applied to this class of deformity, as the following points will demonstrate :—

1. It is difficult, as I have already stated, to draw a sharp line of distinction between congenital fibrous hypertrophies of one kind or another and local gigantism, or even the hemi-hypertrophies affecting the whole of one-half of the body.

2. The majority of fibrous hypertrophies are associated with the presence of dilated lymph-vascular spaces in the fibrous element. It is of interest to note here that Spinner believes that the lymph-vascular dilatation is the

primary developmental fault and that the fibrosis is merely secondary to the resulting increase in nutrition of the part. The dilatation may be merely microscopic or the lymph spaces may form obvious cystic spaces. We are conversant with the ordinary infiltrating type of lymphangioma which is not uncommonly met with as a congenital tumour in the subcutaneous tissue of infants. Here we have numerous cystic lymph-vascular spaces embedded in a stroma of fibrous tissue. At what point can the line be drawn between the fibrous hypertrophy and the lymphangioma? A classification which ascribes a different pathogenesis to two similar processes according to the relative preponderance of the constituent parts of the tumour is likely to keep the truth for ever lost in a maze of words.

A case of fibrous hypertrophy may be associated with the presence of dilated blood-vascular spaces in the tumour, as in Aschoff's 'elephantiasis

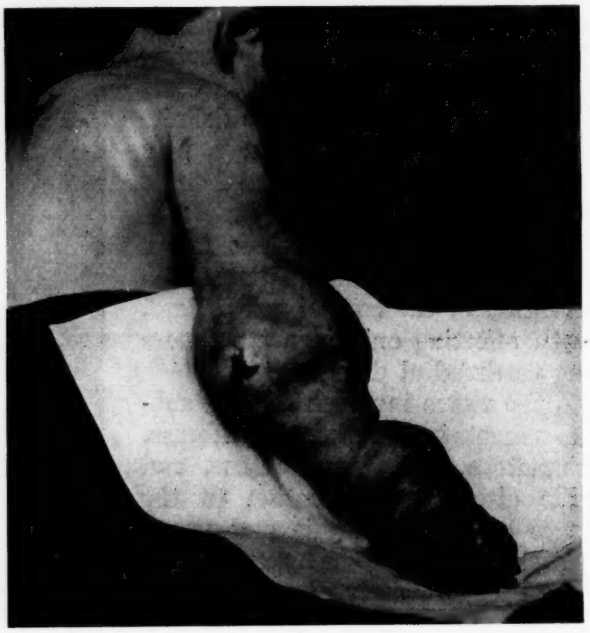

FIG. 274.—Male, age 5½. A case of diffuse cavernous angioma of the right arm. The venous dilatation extends up to and ends sharply at the mid-line of the trunk both anteriorly and posteriorly.

congenita fibrosa angiomatosa'. If the fibrous element is relatively small, the condition receives the name of 'elephantiasis angiomatosa', as in the case depicted in *Fig.* 274, which is neither more nor less than a widespread cavernous angioma affecting the whole of the right arm and sharply delimited by the mid-line of the body anteriorly and posteriorly. It is clear that all intervening stages will be met with, and a classification which tries to separate the congenital enlargements of this type from the simple subcutaneous hæmangioma tends to make confusion worse confounded.

Enough has been said to show the futility of classification into closed compartments where no such compartments exist. One is more likely to

arrive at a true conception of the meaning of these difficult problems by discarding classifications and studying each case independently as a separate embryological problem. By such means we shall probably be able to link up this heterogeneous group of congenital overgrowths with many of the ordinary everyday congenital conditions met with in the out-patient department of a children's hospital.

I should like to acknowledge my indebtedness to Miss G. Herzfeld, F.R.C.S.E., for permission to deal with this case, and to Dr. T. Y. Findlay and Mr. Norman Dott for permission to utilize *Figs.* 273 and 274.

REFERENCES.

[1] SPINNER, A., *Deut. Zeits. f. Chir.*, 1928, ccvii, 421.
[2] ASCHOFF, L., *Pathologische Anatomie*, 1923, 6th ed., i, 649. Jena.

TWO CASES OF LOCALIZED PHLEGMONOUS ENTERITIS.

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Acute localized phlegmonous enteritis involving a small circumscribed area of bowel is a condition which occurs with such rarity that a description of the clinical history, symptoms, and pathological findings in the two cases to be described is worthy of record.

LITERATURE.

Though phlegmonous inflammation of the submucosa of the intestine was described by Rokitansky[1] as early as 1842 there have been remarkably few cases recorded, and as regards British literature we have been unable to find records of a case similar in distribution to our own two examples.

Belfrage and Hedenius[2] record a case in which a man of 52, whose previous health had been good, was admitted to hospital suffering from violent abdominal pain and vomiting and absolute constipation. He died three and a half days after the onset, and at the autopsy a phlegmonous enteritis extending for 18 cm. below the commencement of the jejunum was found. There was an associated purulent peritonitis.

Eskridge[3] reports a case which occurred in a woman of 55 who had suffered from attacks of vomiting and indigestion for fourteen years. The onset of the final illness was sudden, with abdominal pain, vomiting, and a rigor, and death occurred after ten days. She had had a similar attack two months previously. At the autopsy a phlegmonous duodenitis with gangrene of the mucosa was found extending for 12 in. from the pylorus. There was a large stone in the gall-bladder, but this was apparently unconnected with the condition.

Weichselbaum[4] gives a post-mortem report of a case of phlegmonous duodenitis, in which there was great thickening of the bowel wall, with scattered small purulent collections, but no ulceration. There are no clinical notes.

Askanazy[5] reports a case in which a man of 51 was admitted to hospital suffering from severe abdominal pain and died in two days. Fourteen days previous to admission he had fallen from a beam and injured his knee, and since then complained of pains in the trunk. At the autopsy there was serous peritonitis with phlegmonous inflammation of the transverse part of the duodenum. Microscopical examination showed numerous cocci in the bowel wall, and a culture of streptococci and *S. albus* was obtained.

Moisejev[6] records a case in which a man of 67 who had been ill for an unknown length of time was admitted suffering from dyspnœa with pain in the side and acute pleurisy. He died twenty-four hours after admission. At

the autopsy there was phlegmonous inflammation of the first 40 cm. of jejunum, with fibrino-purulent peritonitis. Microscopical examination showed the presence of streptococci.

Matthes[7] describes a case (female of 53) which was fatal from cirrhosis of the liver with ascites, complicated by an ulcer of the leg with surrounding erysipelas. At the autopsy it was found that the entire small and large intestine was the seat of phlegmonous inflammation, the maximum intensity being in the first 32 cm. of the small intestine below the ampulla of Vater. There was an associated fibrino-purulent peritonitis, with acute lymphadenitis of the mesenteric and retroperitoneal glands, and infiltration of the mesentery with seropus. A pure culture of streptococci was obtained.

Deutelmoser[8] reports a case in which a man of 21 was admitted to hospital complaining of jaundice, vomiting, and abdominal pain and tenderness. Symptoms had commenced fourteen days previously. The patient died forty days after onset, and at autopsy a phlegmonous inflammation of the duodenum was found, this being maximal in the neighbourhood of the ampulla of Vater. The head of the pancreas was œdematous and the surrounding lymph nodes were inflamed, but there was no peritonitis. Microscopical examination of the bowel showed large numbers of streptococci.

MacCallum[9] describes a case in which a man of 75 was admitted to hospital complaining of violent pain in the upper part of the abdomen and incessant vomiting of bile-stained material. He had been run over by a wagon three weeks previously and had suffered head injuries; he complained of abdominal pain at this time. The patient died two days after laparotomy, and at the autopsy it was found that a phlegmonous enteritis extended for 5 cm. below the pylorus for a distance of 30 cm. Localized peritonitis was present. Microscopically, myriads of streptococci were demonstrated in the bowel.

Ungermann[10] describes a case in which a man of 60 was admitted to hospital with a history of violent abdominal pain and vomiting of sudden onset, together with jaundice. The patient died in coma after three days. Autopsy showed a phlegmonous inflammation of the duodenum and adjacent parts of pylorus and duodenojejunal junction; this was most marked in the descending part of the duodenum. Close to the ampulla of Vater there was a diverticulum, the walls of which were the seat of a dense purulent inflammatory process. Lying free in the floor of the diverticulum were some sharp splinters of bone. There was marked œdema of the tissues surrounding the duodenum and a diffuse purulent peritonitis was present. The liver showed a portal infiltration with pus cells. On microscopical examination of the bowel large numbers of streptococci were found. This was most marked round the ampulla of Vater.

Ingier[11] states that localized phlegmonous enteritis is a rare complication of lobar pneumonia, and quotes a case in which a man who died from lobar pneumonia had a localized phlegmon of the cæcum and ascending colon, 12 cm. in length. Pneumococci were demonstrated in the bowel wall.

Taylor and Laking[12] describe a case in which a woman of 66 was admitted to hospital suffering from abdominal pain and repeated vomiting of thirty-six hours' duration. Laparotomy was performed, and infiltration of the duodenal

wall noted. Death occurred thirty-six hours after operation. At the autopsy there was found a phlegmonous enteritis of the second part of the duodenum. In the midst of the affected area there was a fish-bone partly buried in the mucosa. A pure culture of *B. coli* was obtained from the duodenal wall and also from an effusion at the base of the right lung.

Dowd[13] reports a case in which a man of 23, who had suffered from intermittent pain in the left side of the abdomen for one year, was admitted to hospital complaining of acute abdominal pain and passage of blood per rectum. The onset was two and a half days previously. At laparotomy the whole of the descending colon was found to be the seat of a purulent inflammation, and was resected. The patient made a good recovery. On microscopical examination of the colon a phlegmonous inflammation with Gram-positive cocci was found.

Frising and Sjövall[14] quote two cases. In the first, a woman of 57 was admitted suffering from violent abdominal pain, bile-stained vomiting, and shivering of twelve hours' duration. Previous health was good. At the autopsy a phlegmonous inflammation of the duodenum and a few centimetres of jejunum was found, associated with œdema of the head of the pancreas and purulent infiltration of the retroduodenal tissues. Part of a fish-bone was found in the duodenal contents. On microscopical examination numerous streptococci were found in the bowel wall.

In the second case, a female lunatic of 73 was admitted suffering from severe abdominal pain, bilious vomiting, and shivering. She died the day after admission. At the autopsy a phlegmonous inflammation of the duodenum and 1 cm. of jejunum was found. This was most marked in the descending part of the duodenum. A diverticulum was present, close to the ampulla of Vater. There was purulent infiltration of the head of the pancreas and the retroduodenal tissues. There was no peritonitis. On microscopical examination of the bowel wall abundant streptococci were found.

Müller[15] describes a case in which a man of 51, whose previous health had been good, was admitted to hospital suffering from violent abdominal pain of sudden onset. At operation the appendix was slightly inflamed and was removed. There was abundant turbid effusion in the pelvis. The patient died the following day. At the autopsy some perityphlitis was present and there was acute generalized peritonitis. A phlegmonous inflammation was present in a high coil of the jejunum and there was a large abscess between the leaves of the mesentery. Streptococci were demonstrated in the affected jejunum and in the mesentery.

Von Saar[16] reports two cases. In the first a man of 21 was admitted to hospital complaining of severe pain in the right side of the abdomen, vomiting, and absolute constipation. He had suffered from epigastric pain after food for some years previously. At operation there was found acute generalized peritonitis with much turbid effusion. The whole of the ascending colon was the seat of phlegmonous inflammation. It was brought out and fixed in the abdominal wound, and was later removed with a Paquelin's cautery. The patient made a good recovery, and continuity of the bowel was restored in five weeks.

In the second case, a man of 44 was admitted to hospital with a five days' history of constipation, colicky pains in the abdomen, and vomiting foul-smelling material. His previous health was good. At operation a high coil of jejunum about 13 in. long was found to be the seat of phlegmonous inflammation. There was an associated patchy fibrinous peritonitis on the parietal peritoneum. The mesenteric glands were inflamed. The affected coil of bowel was packed off, and the patient died three days later. At autopsy the diagnosis of primary phlegmonous jejunitis was confirmed.

Black[17] reports two cases. In the first a woman of 53, previously healthy, was admitted suffering from severe upper abdominal pain and persistent vomiting. She had had a rigor. At operation twenty-four hours after onset, plastic peritonitis round the duodenal area was noted. Drainage was employed, but the patient died shortly afterwards. At the autopsy phlegmonous inflammation of 8 in. of duodenum was found, starting 2½ in. from the pylorus. Cultures from the liver, spleen, and duodenal wall grew streptococci.

In the second case, a man of 55 was admitted suffering from abdominal pain and vomiting followed by a rigor. He had had attacks of abdominal pain and vomiting for years. The vomiting continued, and there was a second rigor thirty-six hours after the onset. At operation the whole of the duodenum and 8 in. of the jejunum were found to be the seat of phlegmonous inflammation. A posterior gastrojejunostomy was performed, but the patient died thirty-two hours after operation.

Glaus[18] describes a case in which a man of 53 was admitted to hospital suffering from some (?) pulmonary condition with dry cough. Beyond some meteorism there was no evidence of abdominal disease. The patient died after a short illness. At the autopsy chronic pulmonary tuberculosis of cavernous nodose type was found, with tuberculous disease of the peritoneum, suprarenals, liver, and spleen. Gall-stones were present. In the lower part of the ileum there was a localized phlegmonous enteritis. The spleen showed acute splenic tumour, and a culture of *S. pyogenes aureus* was obtained. The wall of ileum showed purulent inflammation with Gram-positive cocci and Gram-positive bacilli. The interest of this case lies in the clinical latency of the condition.

Hellström[19] gives a full account of phlegmonous enteritis, and quotes five cases. In the first case a man of 42, previously healthy, was admitted with a three days' history of abdominal pain which increased in severity, vomiting of foul-smelling material, and finally absolute constipation. He had a rigor at the onset. At operation phlegmonous inflammation was present in a high coil of jejunum, together with localized peritonitis. The affected coil was isolated and jejunostomy performed. The patient died shortly afterwards, and at autopsy it was found that the first 30 cm. of jejunum was affected.

In the second case, a man of 55, previously healthy, was admitted complaining of violent abdominal pain. There was tenderness on rectal examination. At operation purulent peritonitis was present. Drainage was employed, but the patient died three days later. At the autopsy a portion of jejunum 10 cm. in length, and commencing 30 cm. below the duodenojejunal flexure,

was found to be the seat of phlegmonous inflammation with associated sero-fibrinous peritonitis. The related mesentery was thickened and the lymph nodes were inflamed.

The third case occurred in a woman of 54, previously healthy save for an operation for gangrenous appendicitis thirteen years previously, this being followed by a ventral hernia. She was admitted suffering from violent abdominal pain and bilious vomiting, and this was followed by a rigor. At operation twenty-four hours after onset turbid effusion was present in the peritoneum, and a fistula was found between the duodenum and gall-bladder. The latter was removed and the duodenum sutured. As the lumen of duodenum was so much narrowed a gastro-enterostomy was performed, but a portion of jejunum 30 cm. long was inflamed and thickened and had to be resected. The patient died thirty-nine days later. At the autopsy a portion of jejunum 60 cm. below the duodenojejunal flexure was the seat of phlegmonous inflammation, and there was an abscess between the leaves of the related mesentery.

The fourth case was that of a man of 37 who had had symptoms suggestive of a gastric ulcer for one year. He had also complained of bloody stools and tenesmus during this time. Twenty-four hours before admission he collapsed with severe pain in the left lumbar region and vomiting. The bowels were loose. Laparotomy was performed, but no free fluid was found. Complete anuria occurred and renal decapsulation was performed on the next day. At this operation it was found that the whole of the descending and pelvic colon, especially at the sigmoid flexure, was swollen; the wall of the bowel being bluish-red in colour. The patient died the next day. At the autopsy the peritoneal cavity was found to contain clear serous fluid. The colon, from the left colic flexure to the rectum, was the seat of phlegmonous inflammation. The mesocolon was swollen and the retrocolic tissues were œdematous. The kidneys showed acute nephritis. On microscopic examination there was purulent inflammation of the wall of the colon, and numerous streptococci together with Gram-positive putrefactive organisms were present.

The fifth case occurred in a man of 46 who had had digestive troubles for many years. His symptoms had become worse fourteen days prior to admission. He complained of violent abdominal pain and vomiting. At the operation an opalescent exudate was present below the transverse colon and it was found that 30 cm. of a high coil of jejunum was swollen and inflamed. The inflammatory process commenced 40 cm. below the duodenojejunal junction. The affected loop was excised and lateral anastomosis effected. The patient died two days later, and at the autopsy the diagnosis of phlegmonous jejunitis was confirmed. The mesentery was thickened. Streptococci were demonstrated in the bowel wall.

Adams[20] reports one case which occurred in a man of 68 who had had dyspepsia of some months' duration. He was admitted to hospital with a seven days' history of intermittent epigastric pain, vomiting, and passage of offensive blood-stained stools. At operation it was noted that most of the coils of small intestine were gangrenous. At autopsy most of the small and large bowel was swollen and œdematous. There was no mesenteric thrombosis.

Bohmansson[21] in reviewing the Continental literature records 68 cases of acute purulent inflammatory processes in the submucosa and subserosa of the intestines, including 11 cases collected by himself.

Analysis of the recorded cases as regards the site of the lesion gives the following figures :—

	No. of Cases	Per cent
Entire gastro-intestinal tract ..	1	1·5
Duodenum	18	26·5
Free part of small intestine ..	19	28·0
Colon	30	44·0

The distribution of Bohmansson's own cases was as follows :—

Ileum	6
Cæcum	1
Descending colon ..	1
Duodenum	3

On referring to the above 11 cases, it would appear that only in some of them were the clinical and pathological investigations sufficiently thorough to allow of a definite diagnosis of phlegmonous enteritis being made.

CASE RECORDS.

Case 1.—The patient, a somewhat obese male, age 51, a foy boatman by occupation, was admitted to the Royal Victoria Infirmary at 4 p.m. on Jan. 17, 1931.

HISTORY.—Up till four days before admission he had led an active and healthy life and gave no history of previous disease. His first symptom was pain of sudden onset, localized to the epigastrium and accompanied by marked shivering and later sweating. The pain was intermittent and recurred in the vicinity of and immediately above the umbilicus. A few hours after the onset vomiting began and continued with increasing severity up till his removal to hospital. The bowels were constipated and there had been no movement for three days, and for two days he had not passed flatus.

ON EXAMINATION.—The patient was cold and collapsed, with a feeble thready pulse of 120 and a temperature of 100°. The tongue was dry and thickly coated, and he was vomiting foul-smelling material at intervals. The abdomen was distended and tender throughout, with maximum pain in the umbilical region. There was no visible peristalsis. The hernial sites were normal, and rectal examination showed nothing abnormal. There were no indications of cardiovascular or of respiratory disease. A tentative diagnosis of mesenteric thrombosis was made and immediate operation carried out.

OPERATION.—A mid-line incision above the umbilicus was employed. On opening the peritoneum marked suppurative peritonitis with much effusion was found. The omentum was found to be firmly adherent to a loop of small bowel. This was freed, and about 9 in. of bowel was seen to be œdematous, enormously thickened, acutely inflamed, and covered with patches of adherent lymph. The vessels were inspected and found to be pulsating normally. The bowel on either side of the affected area was somewhat distended. A lateral anastomosis between loops immediately above and below the thickened area was carried out and tube drainage employed. The patient's general condition was bad, and he did not rally after the operation, dying twenty hours later.

PATHOLOGICAL INVESTIGATION.

A post-mortem examination (No. 23/31) was performed on Jan. 19, 1931. The following report includes only relevant matter :—

Peritoneal Cavity. — Marked acute generalized peritonitis was present, especially in the upper part of the cavity. There was considerable turbid effusion.

The great omentum and coils of small intestine were pasted together with inflammatory exudate. Twelve inches below the duodenojejunal junction was a dilated, œdematous, and congested portion of jejunum which had been isolated by lateral anastomosis. This was removed intact. The bowel above the anastomosis was dilated, but below the anastomosis it was almost empty in parts. There was no gross abnormality in the large intestine. The stomach was markedly dilated and contained foul-smelling material. Beyond numerous petechial hæmorrhages beneath the mucosa there was nothing else abnormal in the stomach or duodenum.

The spleen, liver, kidneys, suprarenal glands, and pancreas showed no special gross changes other than those attributable to toxæmia. The urinary bladder and prostate gland showed nothing abnormal. There was nothing abnormal in the aorta or inferior vena cava or in their branches.

Thoracic Cavity.—There was no evidence of pleurisy or pericarditis. The heart showed no abnormality beyond some dilatation of the right auricle, atheroma of the first part of the aorta and coronary arteries, and toxic changes in the myocardium. There was nothing abnormal in the main bronchi, pulmonary artery, or lymph nodes at the root of the lungs. The lungs on section showed marked terminal passive congestion and œdema at the base on both sides. There was no evidence of pneumonia or tuberculosis.

Portion of Jejunum removed at Post-mortem.—

Anatomical Description.—The affected loop of jejunum was 10 in. long. It was distended with fluid and appeared to be œdematous. There was evidence of early acute peritonitis. It was pale in colour, but the superficial vessels were congested and there were numerous subperitoneal petechial hæmorrhages. This was most marked on the lower portion of the posterior aspect of the loop. Throughout the affected portion of bowel many small yellowish areas could be seen shining through the peritoneal coat. The bowel above and below the affected loop showed no special change save some dilatation of the superficial vessels. On dissection of the main vessels supplying the affected loop no evidence of embolism or thrombosis could be found. There was no special change in the mesentery of the affected loop. On opening the bowel a large amount of thick yellowish fluid escaped which had a faint mawkish odour. A 'window' was cut in the anterior aspect of the loop so as to expose the interior of the bowel (*Fig.* 275). There was no evidence of the presence of a foreign body. In the central portion of the specimen for an extent of 7½ in. the bowel wall was found to be greatly thickened, varying from ⅛ in. to ½ in. in places, the measurement being taken from the peritoneal coat to the tips of the valvulæ conniventes (*Fig.* 276). The remainder of the bowel at each end of the specimen showed no gross abnormality. The thickening was mainly at the expense

Fig. 275.—*Case* 1. Portion of jejunum removed at post-mortem.

of the submucous tissues and mucous membrane, but the peritoneal and muscular coats were also abnormally thick and were dark in colour, being in strong contrast to the submucosa and mucosa, which were intensely pale and had a vitreous appearance in some places. The normal mucosal folds were exaggerated,

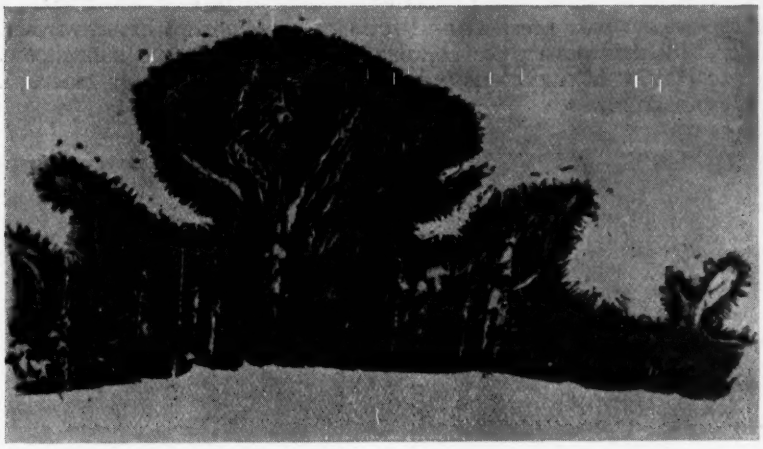

FIG. 276.—*Case* 1. Longitudinal section through wall of jejunum. (× 3.)

and in one place situated at the upper portion of the loop the mucosa was thrown up into folds so as to suggest a polypoid growth. The superficial layers of the mucosa showed extensive desquamation with hæmorrhage, and were necrotic in parts, the appearances indicating an intense inflammatory process, phlegmonous in type.

HISTOLOGICAL DESCRIPTION.—Sections were stained with hæmatin and eosin, and hæmatin and van Gieson.

1. *Mucous Membrane.*—This was thrown up into regular folds, and there was no evidence of neoplasm either simple or malignant, or of a granulomatous condition. Under the low power the villi were seen to be swollen and elongated and to be more cellular than normal. Inflammatory œdema was marked, especially in relation to the acini of the glands. There was extensive desquamation of the elements of the mucosa, and in some places there was superficial ulceration, the villi being destroyed and being replaced by a hæmorrhagic inflammatory exudate (*Fig.* 277). The connective tissue separating the mucosa and submucosa was, however, intact. Under the high power the mucosa showed degenerative changes which varied between intense cloudy swelling and nuclear degeneration and complete necrosis. The blood-vessels of the villi were congested and showed proliferation of the reticulo-endothelial cells lining their walls, and in the stroma of the villi was a cellular and fibrinous inflammatory exudate in which both polymorphs and mononuclear macrophages were abundant.

FIG. 277.—*Case* 1. Mucosa of jejunum showing ulceration. (× 70.)

2. *Submucous Tissue.*—Under the low power the submucous connective tissue could be clearly made out, but was congested and infiltrated with a cellular and fibrinous exudate similar to that described above. The remainder of the submucous tissue was represented by a cellular mass extending in a broad band up to the muscular coats of the bowel (*Fig.* 278). Threads of fibrin were interspersed throughout the mass, and in some places the exudate was purely fibrinous. Extensive inflammatory œdema was present, and numerous congested blood-vessels could be seen. Under the high power the cellular constituents of the submucous exudate were found to consist of numerous polymorphs and mononuclear macrophages, the former predominating.

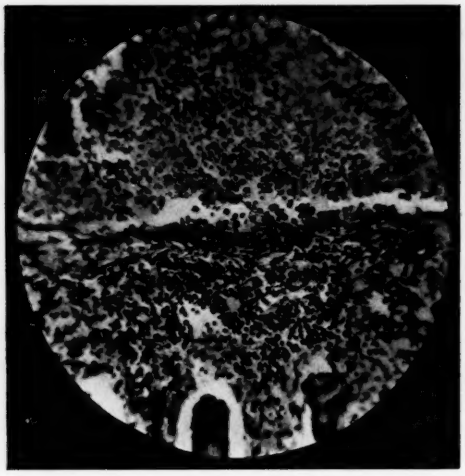

FIG. 278.—*Case* 1. Mucosa and submucosa of jejunum showing inflammatory exudate. (× 210.)

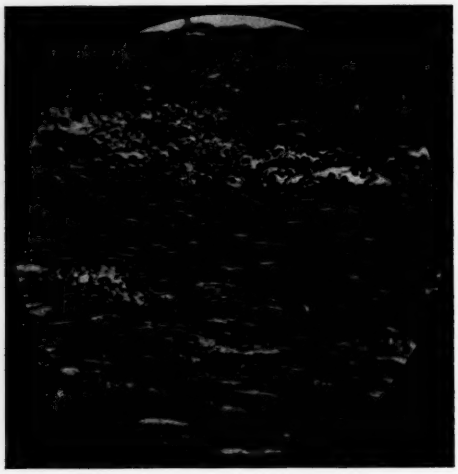

FIG. 279.—*Case* 1. Peritoneal and longitudinal muscle coats of jejunum showing inflammatory exudate. (× 210.)

3. *Muscular and Peritoneal Coats.*—Under the low power the muscle bundles of the circular coat were widely separated by extension of the inflammatory process from the submucosa, and similar appearances were seen in the longitudinal coats. The peritoneal coat was also the site of a cellular invasion, was intensely congested, and showed superficial erosions. Under high power the muscle fibres of the circular and longitudinal coats showed intense cloudy swelling and degenerative nuclear changes. The serosa cells of the peritoneal coat were swollen and disintegrated in many places. The character of the cellular exudate was similar to that described above (*Fig.* 279).

FIG. 280.—*Case* 1. Exudate in submucosa showing inflammatory cells and streptococci. (× 645.)

BACTERIOLOGICAL EXAMINATION.—Stains used were carbol thionin, Gram, and Gram-Weigert.

Smears from Bowel Contents.—These showed numerous streptococci in short-chained and diplococcal forms, together with Gram-positive and Gram-negative bacilli. Many degenerate leucocytes were present.

Smears from Surface of Mucosa.—These showed similar appearances, but the streptococci were relatively more numerous.

Section of Bowel Wall.—In relation to the mucosa comparatively few organisms were present, these being mainly Gram-positive bacilli. On passing towards the submucosa enormous numbers of streptococci in diplococcal and short-chained forms were seen (*Fig.* 280). Phagocytosis was active. Bacilli were practically absent in the submucosa. Organisms were very scanty in the muscular and peritoneal coats, but were seen in relation to the cellular exudate which was separating the muscular bundles.

Cultural examination was not undertaken.

Case 2.—We are indebted to Professor G. Grey Turner for access to his notes of this case and to the specimen which he has preserved.

History.—The patient, a male, age 65, a farmer by occupation, was admitted to Professor Turner's private hospital on Jan. 25, 1913, with the following history. He had suffered from a large left scrotal hernia of very long standing. Forty-eight hours before admission he had an attack of severe abdominal pain associated with shivering.

On Examination.—The abdomen was very tender all over, but was not distended. The pulse was 100 and the temperature 101·8°. The patient's condition rapidly became worse and he was admitted with a provisional diagnosis of strangulated hernia. On admission he looked like a man dying of peritonitis.

Operation.—The hernial sac was found to contain a large amount of small intestine which was somewhat congested and inflamed. There was no actual strangulation, and it did not appear that the severe symptoms could be explained from the state of the hernia. The incision was extended and an affected loop of bowel was found high up on the left side of the abdomen. The appearance of the intestine resembled that of a gangrenous appendix, being greatly swollen, very much thickened, and with yellowish points all over its surface. The conclusion at the operation was that the loop of intestine had been inside the hernial sac and had not recovered after its return to the abdomen. As the patient was extremely ill the loop was surrounded with tissue drains and the abdomen closed. He became steadily worse and died about twelve hours later.

PATHOLOGICAL INVESTIGATION.

At the autopsy the loop of bowel was found to be in much the same condition as at the time of the operation. It proved to be a part of the upper jejunum and could not by any chance have been in the hernial sac. Beyond some little peritonitis the rest of the abdominal contents were healthy. The notes state that the heart was diseased, but the precise lesion was not mentioned.

Portion of Jejunum Removed at Post-mortem.—

Anatomical Description.—The specimen consisted of a portion of jejunum 14 in. long, together with the mesentery in relation to it (*Fig.* 281). A 'window' had been cut in the bowel so as to expose its interior. The central portion of the specimen, 5½ in. long, showed great thickening of the bowel wall varying from ⅜ in. to ⅝ in. in places, the measurement being taken from the peritoneal coat to the tips of the valvulæ conniventes. The remainder of the bowel at each end of the specimen showed no gross pathological change. In the affected portion the valvulæ conniventes were thrown up into polypoidal masses, and the thickening was mainly confined to the mucosa and submucosa, though the muscular and peritoneal coats were also abnormally thick. The submucosa was yellowish-white in colour but in some places was discoloured from altered blood. The surface of the mucosa was the seat of intense inflammatory change and was completely necrotic in places, and there was evidence of considerable superficial hæmorrhage.

Examination of the external aspect of the entire specimen showed the presence of diffuse purulent peritonitis, most marked over the thickened portion. In the latter area numerous extensive purulent deposits could be seen shining through the peritoneum. The distribution of these deposits suggested the presence of a purulent

lymphangitis spreading towards the mesenteric aspect of the bowel. In this area there was a mass of acutely inflamed lymph nodes. Numerous small subperitoneal hæmorrhages were present, especially at the antimesenteric border of the thickened portion. Dissection of the main vessels supplying the bowel failed to reveal any evidence of embolism or thrombosis, nor did the colour of the bowel suggest that vascular obstruction had been the cause of the condition.

The gross appearances of the specimen suggested a phlegmonous inflammatory process.

HISTOLOGICAL DESCRIPTION.—Sections were stained with hæmatoxylin and eosin, and hæmatoxylin and van Gieson. Notwithstanding the fact that the specimen had been preserved in glycerin for eighteen years before sections were cut, there was remarkably little obscuration of fine histological detail.

FIG. 281.—*Case* 2. Portion of jejunum removed at post-mortem.

Bowel Wall.—In general the appearances corresponded exactly to those already described under *Case* 1, but the inflammatory process appeared to be more intense. The mucosa showed acute inflammatory change throughout, and in many places the appearance varied between superficial desquamation and ulceration, and complete necrosis. There was no evidence of neoplasm or of a granulomatous condition. The submucous connective tissue was clearly defined, but extending from the mucosa and infiltrating the circular and longitudinal muscle layers was an inflammatory exudate, consisting of polymorphs and mononuclear macrophages interspersed with threads of fibrin. The peritoneal coat showed intense acute inflammatory change with superficial erosions.

Under the high power numerous minute yellowish-brown granules were seen, both in mucosa and submucosa. The appearances suggested the precipitations so frequently seen in old formalin specimens. A positive prussian-blue reaction in some of the granules indicated that hæmosiderin was present, but on treating sections with caustic potash the majority of the granules disappeared.

Section of Mesentery.—This included the main vessels supplying the affected portion of the bowel and also an enlarged lymph node. The main vessels showed no evidence of thrombosis, but the artery was the seat of a marked degree of arteriosclerosis. The lymph node showed acute lymphadenitis with marked reticulo-endothelial hyperplasia and infiltration with polymorphonuclear leucocytes.

BACTERIOLOGICAL EXAMINATION.—Sections were stained with carbol thionin, Gram, and Gram-Weigert.

Section of Bowel Wall.—In relation to the mucosa large numbers of organisms were present, these being mainly Gram-positive bacilli of various types and short-chained streptococci. On passing towards the submucosa the appearances in some places corresponded to a pure culture of streptococci in short-chained and diplococcal forms; few bacilli were present. Phagocytosis was active. Streptococci were abundant in the exudate infiltrating the muscular coats of the bowel, but were scanty in the peritoneal coat.

Mesenteric Lymph Node.—No organisms could be demonstrated.

SUMMARY.

1. Two cases of acute localized phlegmonous enteritis of streptococcal origin are reported.

2. In common with many of the cases recorded there was a sudden onset associated with a rigor and acute abdominal symptoms suggestive of acute intestinal obstruction.

3. There was a rapidly fatal termination with peritonitis.

4. Vascular obstruction and foreign body were excluded as etiological factors, and there were no indications of pyæmic deposits elsewhere in the body.

5. Pathological investigation suggests an autogenous infection possibly resulting from local injury of the bowel wall.

We are indebted to Mr. Trevor Barnett and to Mr. A. R. D. Pattison for valuable assistance in reviewing the literature relative to phlegmonous enteritis.

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SPONDYLOLISTHESIS.*

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DISPLACEMENT of the presacral spine forwards upon the sacrum has attracted a great deal of attention since the name of spondylolisthesis was applied to it by Kilian in 1854. In the latter half of the nineteenth century those chiefly interested were the obstetricians, who, stimulated by the work of Neugebauer, recognized the lesion as an occasional cause of difficult labour. With the advent of roentgenology fresh interest was aroused, and it has become apparent that this condition is at least as common in men as it is in women. A further development has been provided by improved lateral roentgenography of the spine, which has made possible the detection of lesions not seen in antero-posterior views. At the present time spinal lesions are being increasingly investigated because of the onslaught of the motor-car and of other mechanical devices. In view of its possible relation to trauma, the subject of spondylolisthesis occasionally provides material of medico-legal interest.

The present paper is based upon a study of 34 cases of spondylolisthesis, and of anatomical and roentgenological material, with special reference to the mechanics of the lesion and to its diagnosis. The main features of interest are summarized in the following table :—

	Cases	
Males (53 per cent)	18	
Females (47 per cent)	16	
Under 25 years of age (youngest 11)	13	
Between 25 and 50	15	
Over 50 years of age (oldest 71)	6	
Spondylolysis with displacement	23	
Forward displacement of entire 5th lumbar vertebra ..	6	34
Displacement of 5th, but of uncertain type	5	
Early cases—mild displacements	9	
Spina bifida present	15	
Sciatica prominent symptom	12	
Severe injury to spine	3	
Moderate injury to spine	6	

Types.—There are two types of spondylolisthesis. The first is one that is often described in text-books and occasionally in journal articles, but is rare. In this practically the entire 5th lumbar vertebra slips forwards upon the sacrum and carries the rest of the spine with it. The second type, the one which is most frequently seen, and which was well recognized by Neugebauer as well as by most modern writers, consists in the separation (or spondylo*lysis*) of the 5th lumbar vertebra into two portions by a solution of bony continuity in the laminæ posterior to the transverse processes, in such a way

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that the part bearing the spinous process and inferior articular surfaces moves backwards and the rest of the vertebra slips forwards upon the sacrum. This is the condition discussed in this article.

Literature.—There have been written, up to the present time, about 250 articles upon this subject, a considerable number being of German or American origin. Until 1900 almost all of them were based upon descriptions of museum specimens, the pioneer work being carried out by Neugebauer. In England, Lane in 1885 discussed spondylolisthesis as one of the numerous changes found in the spine of labourers; but one of the best descriptions of pathological material was by Lawrence in 1900. The remarks by Blacker supplemental to Lawrence's paper are of importance, as he clearly appreciated that the site of bony defect was in the interarticular portion of the laminæ of the 5th lumbar vertebra. Of modern British clinical and roentgenological work, that by Brailsford is the most noteworthy. In America in 1912, following a description of a case, Fitch gave an important list of 161 references to the literature. In recent years Whitman, Albee, Kleinberg, and Willis have made valuable contributions. An article by Meyerding in 1931 reporting 121 cases is of great interest from the clinical point of view. In this series 62 per cent of the patients were males. In 1928 Faldini in Italy made an excellent contribution to the study of spondylolisthesis. He applied a different title to each of the two types of lesion: for the rare slip of the entire 5th lumbar vertebra he reserved the name 'spondylolisthesis'; for the commoner lesion he used the title 'spondylolysis'.

The Congenital Nature of the Basic Lesion of Spondylolisthesis.—Many writers have noted the congenital nature of the defect in the laminæ of the last lumbar vertebra. The most extensive investigation is by Willis, who has reported upon a series of over 700 skeletons, and finds such defects in the neural arch of 4·28 per cent of individuals. It has often been stated that the neural arch of the last presacral vertebra, instead of being developed from two primary centres of ossification, may have four, one for each pedicle and superior articular process and one for each lamina, and that it is failure of the latter to fuse with the former that permits the common form of spondylolisthesis to occur. Willis suggests that although such a congenital origin is probably the only satisfactory explanation of these lesions, yet the embryological evidence upon which this statement should be based is very weak.

What Part does Trauma take in the Development of Spondylolisthesis?—Assuming the presence of a congenital defect, it cannot, however, be denied that trauma plays an important part in the further development of spondylolisthesis. Can this condition, on the other hand, develop as a purely traumatic lesion? The answer is at present unsatisfactory, as a study of the literature reveals that no one has presented a case in which trauma has been proved to be the causal factor to the extent that, as the result of the injury, spondylolisthesis can be shown to have developed in a spine known by previous X-ray examination to have been normal. Furthermore, the majority of cases or specimens reported upon have been advanced lesions, and no demonstration has been made of the progression in the same patient from the pre-slip stage to a well-marked spondylolisthesis. Reports have,

however, been published of cases in which the deformity has occurred in spines previously stated to have been normal clinically (Kleinberg, Turner).

It is obvious, however, that mechanical strain must be of influence, and it is probable that the greatest part is played by the ordinary influences of gravity that everyone is subjected to, though a history of violent injury to the back is presented by some patients.

Emphasis has been placed upon the increased tilt of the sacrum towards the horizontal in the production of spondylolisthesis. In fact, Armitage Whitman has described several cases of pre-spondylolisthesis in which this was a prominent factor. While not denying the existence of this and of the consequent increase in the shearing stress exerted at the lumbosacral joint, I believe that certain other details must be borne in mind. At the inception of the condition lordosis may be absent. In support of this are the following facts: The commoner types of injury complained of by those patients in whom trauma is a prominent feature are: (1) The lifting of heavy weights; (2) Falls to the ground upon the buttocks; and (3) The fall of heavy weights on to the shoulders. In none of these is lordosis likely to occur; in fact, in all of them it is an almost impossible position. In lifting a heavy weight, a man starts with his hips flexed and the lumbar spine arched backwards. Elevation of the load is largely carried out by use of the gluteus maximus muscles with extension of the hips. Thus the sacrum is actively tilted backwards and forced against the laminæ of the 5th lumbar vertebra. When an individual is forced to sit suddenly on the ground, the lumbar spine becomes flexed so that the normal curve is obliterated. If a load is suddenly forced on to the shoulders or upper back, the patient 'caves in' forwards; in other words, he collapses with the lumbar spine again held in extreme flexion. So-called traumatic spondylolisthesis usually occurs in men, in whom lordosis in extreme form is not so commonly found as in women. In the examination of the early cases in young adults where slipping has scarcely commenced, I have been impressed by the absence of lordosis. In late cases the lordosis present is, I feel, secondary to the displacement at the lumbosacral joint, and is of a peculiar kind in that the sacrum, instead of being nearly horizontal, is rotated into the vertical position and carries with it the spinous process of the 5th lumbar vertebra (*see Fig.* 289).

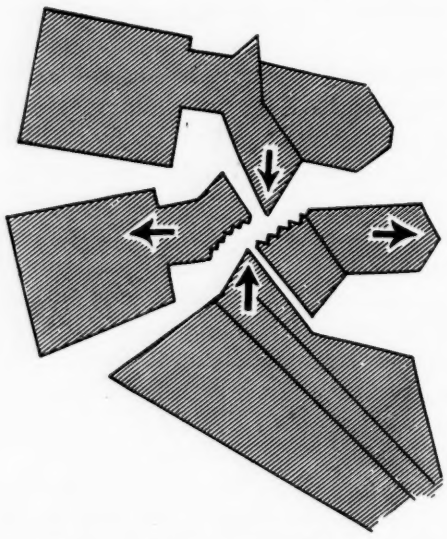

FIG. 282.—Diagrammatic lateral view of lower spine to show the influence of sacral and lumbar wedges upon the last lumbar vertebra.

An important factor that I think has been overlooked is the wedge-like influence provided by the upper and posterior borders of the sacrum (*Fig.* 282). The apex of the wedge is formed by the articular facets of the sacrum,

and this is driven upwards and splits the 5th lumbar vertebra into two portions at the site of congenital non-union. Thus is initiated spondylo*lysis*, and 'spondylo*listhesis*', or slipping, follows through the continuance of the two influences of wedge action and shearing stress.

In the lumbar spine, because of the direction of its curve, weight transmission tends to be displaced posteriorly from the bodies to the laminæ and articular facets, and the laminæ of the 5th will thus tend to be nipped between the sacrum and an upper wedge provided by the lower articular processes of the 4th lumbar vertebra. Such conditions are difficult of demonstration in the resting spine. I am fortunate therefore in being able to present an X-ray (*Fig.* 283) of a lumbar spine where these factors can be studied in a stationary form. The patient had had a long-standing tuberculosis of the upper lumbar vertebræ with severe collapse anteriorly. At the lumbosacral joint a mild spondylolisthesis has commenced. Examination of the illustration, in which the chief lines of

FIG. 283.—Tracing of lateral skiagram of a case of tuberculosis of the thoracico-lumbar junction. Demonstration of tensile and compression stresses and early spondylolisthesis.

FIG. 284.—Tracing of lateral skiagram of cervical spine in a patient with fracture of the atlas and axis showing analogous splitting of vertebræ. (*By courtesy of Dr. F. J. Hodges.*)

force have been indicated by arrows, will reveal how splitting of the 5th lumbar vertebra has probably occurred.

As a demonstration of a somewhat similar wedge action elsewhere in the spine, the case illustrated in *Fig.* 284 is of great interest. In this the 1st and 2nd cervical vertebræ have been split each into two halves at points analogous to the site of the lesion in spondylolisthesis. The apices of the wedges involved are here provided by the condyles of the occiput on the one hand and the anterior edges of the superior articular surfaces of the 3rd cervical vertebra on the other. The cause of this lesion was a motor-car accident.

Spina Bifida.—With one morphological defect, it would not be surprising to find other similar anomalies, and this in fact is true of spina bifida and the

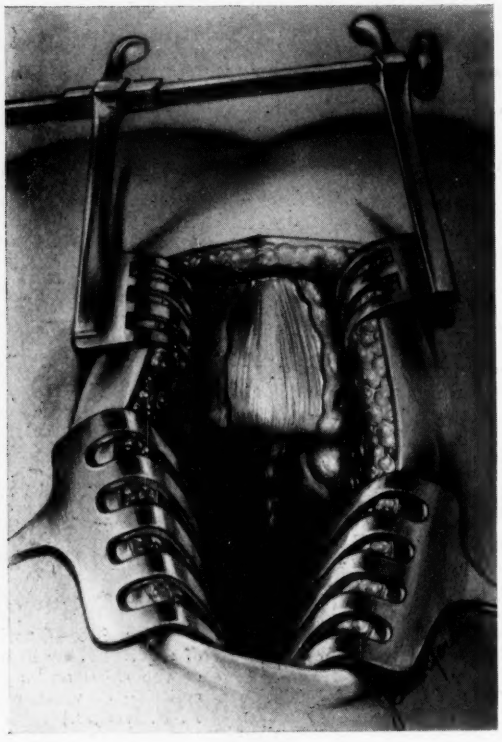

FIG. 285.—View of lumbosacral spine at operation in a case of severe spondylolisthesis, showing wide bony defect in the sacrum.

interarticular defect that is present in spondylolisthesis. While I do not believe that spina bifida bears any causal relation to spondylolisthesis, I find that those cases having wide gaps in the laminæ of the 5th lumbar vertebra or sacrum do show much more severe forward displacement. In *Fig.* 285 is illustrated the type of sacral defect found in two very severe cases of displacement operated upon by the writer.

Rotato-scoliosis.—In spondylolisthesis the amount of displacement is often not symmetrical because the laminal defect may be present on one side only.

In such cases rotato-scoliosis results (*Fig.* 286). This is of great interest, as the lumbar spine is commonly supposed to possess little power of rotation on account of the situation in relation to the sagittal plane of the articular facets. The usual reasoning regarding lumbar rotation assumes that the axis for such

Fig. 286.—Severe spondylolisthesis with rotato-scoliosis.

a movement must lie at the centre of the vertebral bodies. There are several mechanical factors that combine in the lumbar region to make it feasible for the axis of rotation to be placed posterior to the spinal canal. The centre of the circle of which the normal lumbar curve is a segment is situated posteriorly, and it is therefore easier for rotation also to occur upon a posterior

axis. If the lumbar concavity is increased, the centre of gravity is displaced posteriorly in relation to the lumbar vertebral bodies. Supposing that the axis of rotation were to be displaced to the tips of the spinous processes, the

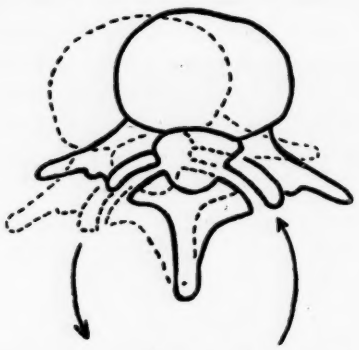

FIG. 287.—Diagrammatic outline of a lumbar vertebra demonstrating in exaggerated form possible rotation upon a posterior axis.

arrangement of the articular facets would be admirably suited to allow of a fair range of movement of this type (*Fig.* 287).

Factors Limiting Displacement.—That the supports of the spondylolisthetic 5th lumbar vertebra are very insecure is obvious; nevertheless in the majority of cases the displaced body comes to a final position of rest after making only a moderate forward movement. There are several factors that favour natural arrest. One of these is provided by the iliolumbar ligaments that pass from the transverse processes of the last lumbar vertebra to the iliac crests; these are assisted by the interspinous ligaments and the posterior spinal muscles. The effect of all these ligamentous structures is increased

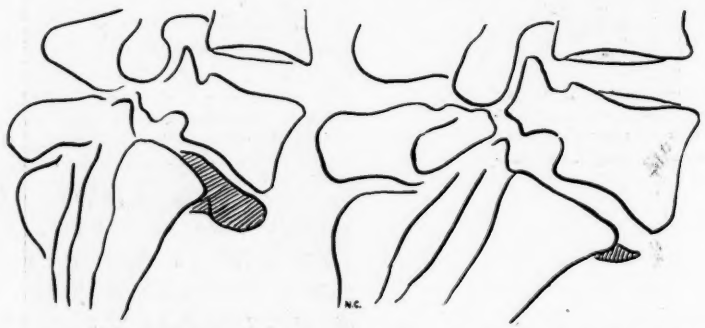

FIG. 288.—Tracings of lateral views of two cases of spondylolisthesis with buttress formation beneath the last lumbar vertebra.

by the tendency of the pelvis to assume a more vertical position by rotation on its transverse axis. Bone often proliferates from the anterior surface of the sacrum beneath the displaced portion of the 5th lumbar vertebra, forming a sufficient buttress to prevent further slip (*Fig.* 288). In many weight transmission must be partly assumed by the laminæ and spinous processes, and it is possible in some for the 4th lumbar vertebra, through its inferior articular facets, to come into direct contact with the sacrum.

Clinical Features.—In well-advanced cases it is usually not difficult to make the diagnosis of spondylolisthesis on clinical examination alone. A

shortened trunk in which the lower ribs are depressed, sometimes almost into the pelvis, is associated with a rotation of the pelvis upon a transverse axis so that the sacrum appears more vertical (*Fig.* 289). There is a small hollow behind the lumbar spinous processes, and at the lower end of this hollow there is a bony projection which in the commonest type of spondylolisthesis is the tip of the spinous process of the 5th lumbar vertebra, and not, as often stated, the upper border of the sacrum. A peculiar waddling gait may be observed; this is due to hyperextension of the hips secondary to the pelvic rotation.

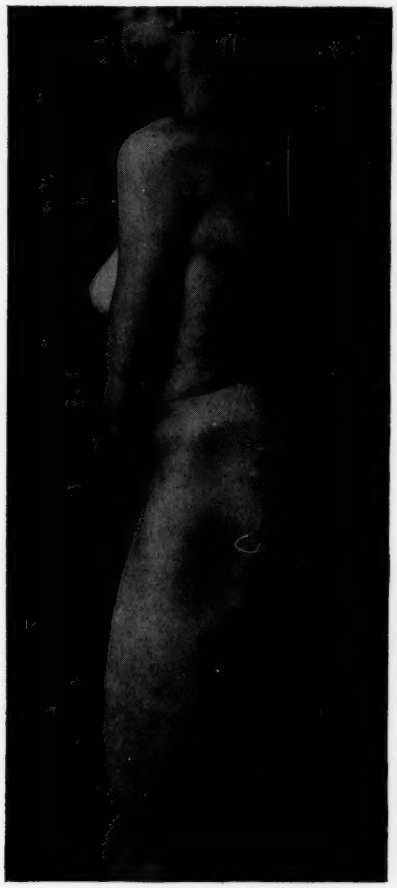

FIG. 289.—A patient with severe spondylolisthesis, showing characteristic rotation of the pelvis upon a transverse axis.

Pressure upon the branches of the cauda equina is not uncommon, and is manifested by sciatic neuralgia or neuritis. In the very early cases, low back pain is a common complaint, but nothing characteristic may be found except a small prominence of the 5th lumbar spinous process.

FIG. 290.—Antero-posterior view of a case similar to that shown in *Fig.* 289.

X-ray Appearances.—For early diagnosis X-ray examination is essential. In the antero-posterior view (*Fig.* 290) the well-developed cases give very characteristic appearances, as is well illustrated in Brailsford's article. The lateral view is of greater importance for early diagnosis, and the following points at the lumbosacral junction must be observed: (1) Alinement of the anterior and posterior borders of the vertebral bodies; (2) Width of the intervertebral disc; (3) Shape of the intervertebral foramina; (4) Continuity

of the neural arches; (5) Length and relation of the spinous processes; (6) Evidence of structural bone changes; (7) Degree of lumbar curve and angle of the sacrum; (8) Evidences of spontaneous arrest.

1. In advanced cases, the forward displacement of the 5th lumbar body is easily seen. Because of the thickness of the intervertebral disc milder projections of the anterior border of the 5th lumbar body may be more difficult to distinguish. For such cases Ullmann has devised a test which is illustrated in *Fig.* 291. Regarding alinement of the posterior borders of the

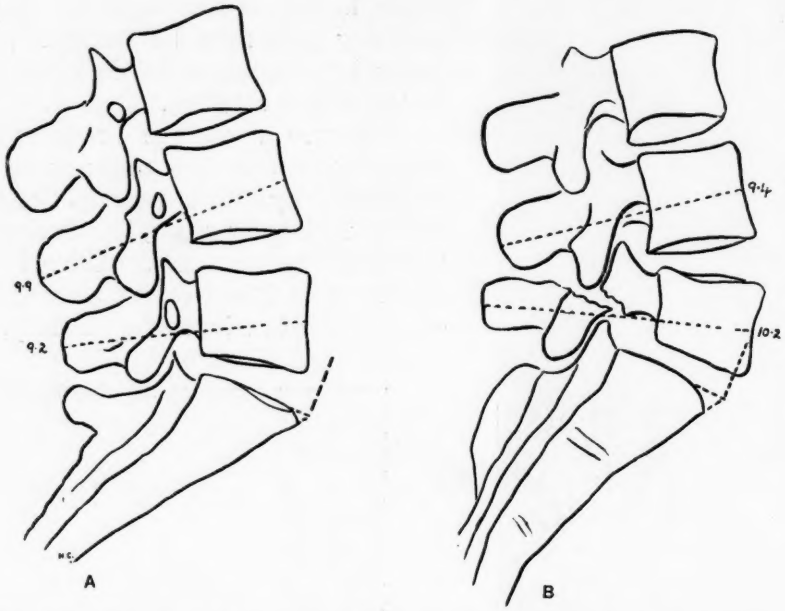

FIG. 291.—Two tests for early spondylolisthesis: (1) Comparison of antero-posterior diameters of last two lumbar vertebræ; and (2) Ullman's sign. In the latter a line is drawn at right angles to the upper border of the sacrum at its anterior edge; the 5th lumbar vertebra should lie entirely behind this line. **A**, Normal spine; **B**, Spondylolisthesis.

vertebral bodies some caution must be exercised in the interpretation of displacement, as a normal joint (because of some obliquity of the X-ray tube) may show an apparent subluxation. This is due to the shadow cast by the lateral mass of the sacrum which may project behind the posterior border of its body.

2. There is often some narrowing of the intervertebral space, which in most cases is probably secondary to the displacement; when due to the destructive lesion of tuberculosis it may be a causal factor in the origin of a spondylolisthesis.

3. The intervertebral foramina of this interval are the smallest of the lumbar series, and in spondylolisthesis are elongated irregularly in the antero-posterior direction.

4. One of the most characteristic features, which is usually seen best in early cases, is the break in the laminæ; this may appear as a gap continuing the lumbosacral intervertebral clear space backwards *above* the spinous process

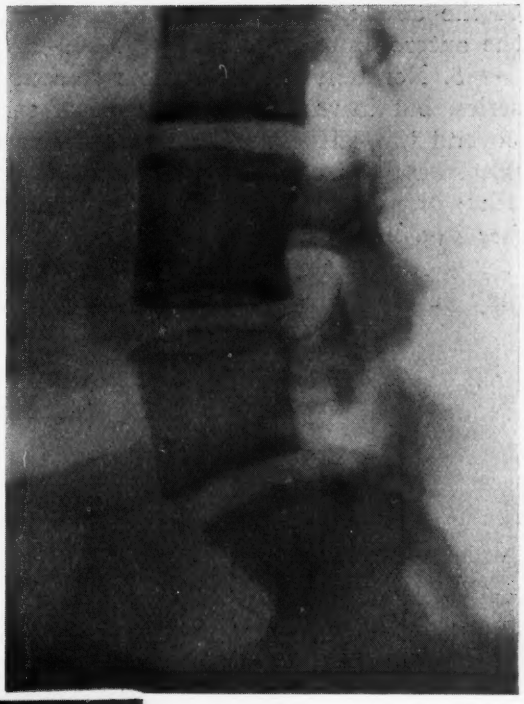

FIG. 292.—Untouched print of a lateral skiagram of early spondylolisthesis. The laminal defect is well shown, but the spinous processes are unfortunately lost in printing.

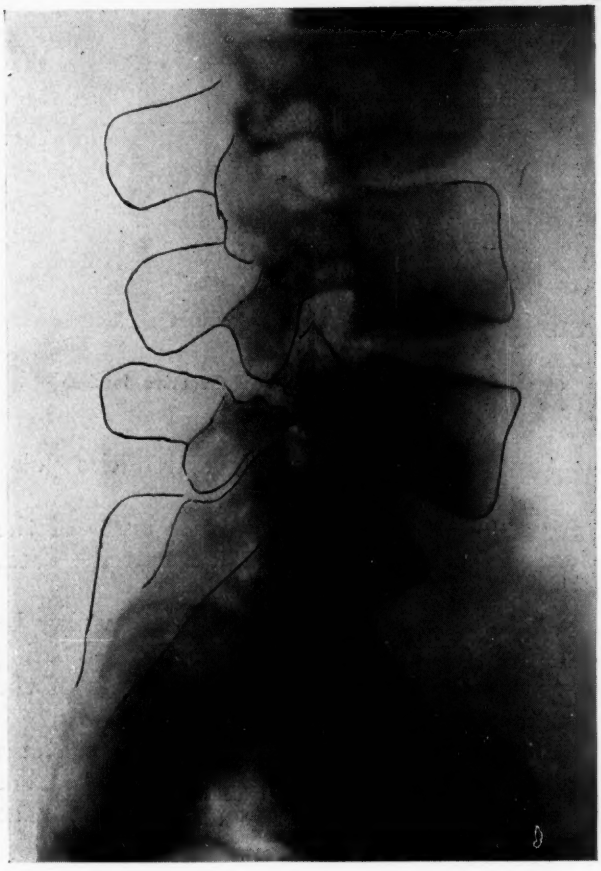

FIG. 293.—A skiagram of a similar case to that shown in *Fig.* 292. Certain of the bony details have been outlined in ink.

of the *5th* lumbar vertebra. Occasionally this defect may be observed in the antero-posterior view (*Figs.* 292–294).

5. Normally the 5th lumbar spinous process is the shortest of the lumbar series, but in the commoner type of spondylolisthesis it projects backwards beyond the 4th spine. A useful diagnostic point is to measure the antero-posterior diameters of the 4th and 5th lumbar vertebræ. In these cases the 5th will usually be found longer than the 4th; a reversal of the normal (*see Fig.* 291).

6. As further evidence of the wedge-like influence of the sacrum there may be found, besides the separation of the lowest lumbar vertebra into two

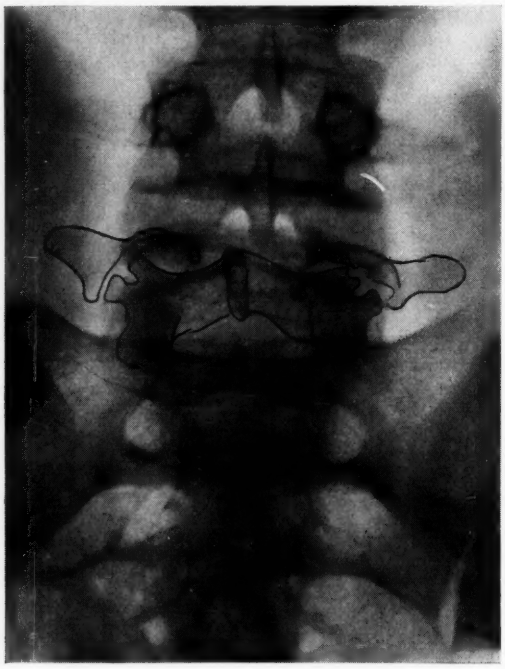

FIG. 294.—Antero-posterior view of same case as *Fig.* 293. The defective laminæ have been outlined.

portions, an angulation of the two halves so that their extremities point downwards.

7. In my experience the degree of lumbar curve and the angle of the sacrum have not been excessive; as already stated, in the extreme cases the latter tends to assûme the vertical.

8. As evidences of spontaneous arrest, bony buttress formation may be seen attached to the anterior surface of the sacrum under the projecting portion of the 5th lumbar vertebra, and the lower articular process of the 4th may rest on the sacrum (*see Fig.* 288).

Treatment.—That many patients have spondylolisthesis without symptoms cannot be denied. In the early cases the temptation is great to try to prevent the further development of the deformity by bone-grafting operations. The

early treatment should, however, be that of any postural backache: the removal of conditions of labour likely to accentuate the lesion, a period of rest, and the provision of a brace where necessary. Operation should be reserved for cases not responding to such treatment or which are giving evidence of further slipping. Bone-grafts undoubtedly assist many patients, but it must be remembered that the result does not, from the mechanical point of view, possess great efficiency. Tremendous forces are brought to bear upon the graft, which is badly placed for the prevention of further slipping. In cases with sacral spina bifida it is difficult to obtain fixation for the graft at the lower end (*see Fig.* 285). The ideal operation would be either an anterior bone-graft so placed as to fix the body of the 5th lumbar vertebra to the sacrum and forming a buttress, or some form of antero-posterior fixation of the two halves of the divided vertebra (*Fig.* 295). The technical difficulties of such procedures, however, preclude their trial.

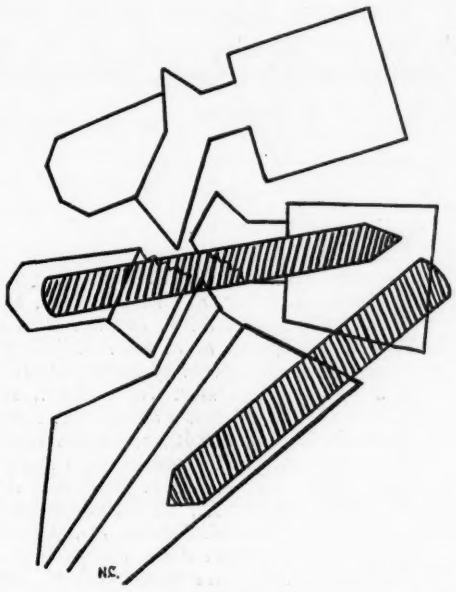

FIG. 295.—Theoretical alternatives to the posterior bone-graft operation for spondylolisthesis.

SUMMARY.

Spondylolisthesis, equally common in men and women, is found to be of two types. The more usual results from a separation, through a probable congenital defect, of the 5th lumbar vertebra into two portions. Besides the forward displacement of the body of this vertebra, its spine and laminæ are displaced backwards with the sacrum.

The place of trauma in producing the subluxation and the influence of other factors besides lordosis are discussed. The author believes that the sacrum acts as a wedge, the apex of which (the upper and posterior edge) is driven upwards and causes a diastasis of the last lumbar vertebra, and that the posterior portions of the lumbar vertebræ take a more active part in the production of spondylolisthesis than is usually recognized.

Factors favouring natural arrest of the displacement are described; the surest of these is the formation of a bony buttress from the front of the sacrum.

Good lateral X-ray studies are frequently the only means of detecting the very early displacements, which will be found to be more common than is usually suspected. Roentgenological tests for early cases are illustrated.

Mechanically ideal, though technically unsuitable, operative procedures

are mentioned and the usual treatment is outlined; this in most cases should first be conservative.

I wish to acknowledge my indebtedness to the late Dr. P. M. Hickey, Professor of Roentgenology at the University of Michigan, who inspired me to carry out this study and who generously placed the resources of his department at my disposal.

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For more complete bibliographies, the reader is referred to the articles by Fitch, Brailsford, and Faldini.

POST-OPERATIVE MASSIVE COLLAPSE OF THE LUNG.*

A CLINICAL AND EXPERIMENTAL STUDY.

By DAVID BAND and I. SIMSON HALL, Edinburgh.

INTRODUCTION.

Modern technique in operative surgery has brought about a great drop in the incidence of complications to surgical cases in the post-operative period. Improved anæsthesia, general or local, pre-operative preparation, the anticipation and treatment of shock, asepsis, gentleness in handling, careful dissection, and intelligent and co-operative after-treatment have all followed increased knowledge of surgical pathology, living pathology, and biochemistry.

With the diminution of the incidence of sepsis, shock, cardiac failure, etc., attention has become drawn to the increasing number of cases in which pulmonary complications are present. In this group are many classes of lesion, but their increasing importance is seen from these figures taken from Cutler, who found the reported incidence of pulmonary complications after operation to be :—

1898	..	.. 0·38 per cent
1916	..	.. 1·86 per cent
1921	..	.. 3·5 per cent and a mortality of 0·5 per cent

That author, from the records of 1562 cases, estimated the case-mortality of a post-operative pulmonary complication at 20 per cent. Of these chest conditions, 76·4 per cent are noted as commencing within forty-eight hours of operation, and they are described under the diagnoses of pleurisy, bronchitis, bronchopneumonia, lobar pneumonia.

In other analyses of pulmonary post-operative complications similar figures are obtained, and the lesions are described under similar headings. One author, Beckman[2] (1910), has given a double analysis of circulatory and lung complications, and it is interesting to note that his figures for phlebitis and pleurisy are closely approximate, viz., 0·38 per cent and 0·33 per cent, almost 60 per cent of the former having the further and more deadly complication of pulmonary embolism. These last figures are of special interest when it is remembered that Cutler, Cutler and Hunt,[11] and Schlueter and Weidlem, in a series of papers, have developed the embolic theory in relation to these pulmonary complications. Bronchitis and bronchopneumonia are alleged to be due to showers of minute emboli released from the lymphatic

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field of the operation area, carried in the lymphatic circulation to the blood-stream, thence to the right heart and lung. A mild pneumonitis is set up, and secondary factors of sepsis, blood-borne or inhaled, determine the severity of the subsequent bronchopneumonia. In animal experiments they were able to control the effect of an embolus artificially introduced via the jugular vein. Different degrees of infecting virus in the artificial embolus produced a mild or virulent pneumonitis; the milder strains, a pulmonary abscess. They blame local chilling, sepsis, asphyxia, acidosis, and the primary disease as the main factors in etiology, while rough handling and irritative anæsthesias also play an important rôle.

The use of the X rays in chest diagnosis, and a closer investigation of the post-operative chest from a clinical standpoint, probably account for the increasing number of collapse cases now reported; so that we have Scott[32] (1925) describing no fewer than forty cases of massive atelectasis. The tabulated facts are :—

Seasonal Influence—nil. *Age*—12 to 49 years; 40 per cent third decade. *Time*—80 per cent within 48 hours of operation. *Duration*—2 to 17 days. *Result*—in this series all recovered. *Site*—75 per cent right lung, usually lower lobe.

Description.—Pain, dyspnœa, tachycardia, cyanosis, cough. Temperature 100°–104·8°. Pulse 108–160. Respiration 30. Thoracic asymmetry—unilateral dullness and displacement of heart to the affected side. Breath-sounds: (1) Diminished, very faint bronchial brèathing; (2) Coarse râles.

X-ray Appearance.—Marked density of affected lung, deviation of heart to affected side, elevation and relative immobility of the diaphragm.

Following the appearance of râles the signs become those of a bronchopneumonia with a thick tenacious sputum.

The types may be classified as: (1) Fulminating; (2) Moderately severe; (3) Latent. They terminate by: (1) Lysis; (2) Complications; (3) Crisis.

In a recently published article on the subject Sheret[34] reports the occurrence of pulmonary collapse in 18·1 per cent of 149 male patients and 13·7 per cent of 112 female patients in their post-operative course.

The condition of massive atelectasis of the lung was recognized by Legendre, Bailey, and others as far back as the middle of the last century. Since that time it received but spasmodic attention till, in 1890, Pasteur[29] described the condition and by his later work established it on a sound basis as a clinical entity.

From this time many complete accounts have been given, notably by Scott,[32] Churchill,[8] Leopold,[25] and others, so that any further complete summary would serve no useful purpose. Perusal of the literature, however, convinces us that, excellent as many of these articles are, the evidence upon which rest the many and various theories advanced is extremely slender when it is judged from experimental or clinical standpoints. The present series of experiments was undertaken to attempt to supplement that evidence and provide a sound basis of experimental proof for one theory of the origin and mechanism of the condition, when met with in its post-operative form, and possibly at the same time to provide some link with other types which at first sight appear unrelated to that just mentioned.

There is no doubt that we owe our knowledge of the ultimate mechanism of collapse to the classical experiments of Lichtheim,[26] whose work, quoted

and described by practically every writer on this subject, proved beyond doubt that the collapse of the alveoli was due to the absorption of alveolar air into the blood-stream. Hence all investigation is directed towards the discovery of conditions or mechanisms which will tend to this result.

The action of drugs on the bronchi has frequently been investigated with a view to ascertaining whether these can play any part in producing an obstructive or tonic condition in the bronchial muscle. Dixon and Brodie[12] in 1903 gave a very complete account of the effects of drugs on bronchial muscle. They point out that chloroform, ether, and atropine tend to dilate the bronchioles, while suprarenal extract produces slight contraction. They further state that no tonic effect was ever observed. Bullowa and Gottlieb[6] mention similar observations carried out with the help of the fluorescent screen and radio-opaque substances.

The diaphragm has been investigated by various experimenters, in a number of cases with the object of disproving Pasteur's original statement that massive collapse was due to the paralysis of the diaphragm. Elliott and Dingley[13] early established the fact that no collapse of the lung follows division of the phrenic nerve or hemisection of the cord at the second or third cervical segments. Hemisection produces paralysis of the intercostals as well as of the diaphragm, in effect depriving the lung on the one side of the chief part of its movement. Schroeder and Green[31] give a very complete account of the effect of phrenicectomy, and add the interesting conclusion that, although there is an innervation of the margin of the diaphragm from the intercostal nerves, this supply is in no way sufficient to carry on the work of the diaphragm after section of the phrenic nerve. Coryllos and Birnbaum[9] also have failed to produce atelectasis after division of the phrenic nerve. More recently Lemon[24] has shown that, although diaphragmatic excursion is affected after phrenic neurectomy, there is no influence on vital capacity.

The influence of the extrinsic nerves of the lung has been dealt with by Fontaine and Herrmann,[16] who succeeded in denervating the lungs of dogs almost completely. Their results are of importance from the fact that they tend to show that there followed no change in respiratory movement, and that severing of the nervous connections did not prevent collapse.

The most interesting experiments, bearing on atelectasis as a post-operative complication, are those of Tucker, Lee, and their co-workers.[22, 23, 35, 36] By simulating the conditions found by actual observation through the bronchoscope in patients suffering from atelectasis, they have reproduced the condition and have been able to study its mechanism and treatment. The mechanism of onset and the appearances of the lung during the production of the atelectasis, as well as the influence of various gases, have been recently studied in an exhaustive manner by Coryllos and Birnbaum. By an ingenious balloon they have been able to occlude the lung at will, and so study the process of atelectasis in detail. The experiments of Lee and Tucker, however, have gone a step farther by attempting to produce, not so much the condition of atelectasis by a known process, but the conditions predisposing to it, and observing the reaction of the lung to these conditions and to the methods of treatment.

REPORT OF FOUR CLINICAL CASES OF POST-OPERATIVE PULMONARY ATELECTASIS.

We are indebted to Professor D. P. D. Wilkie for permission to record the following cases.

Case 1.—J. B., male, age 33 years. This patient was admitted to the Royal Infirmary, Edinburgh, with a history of indigestion over a period of ten years. A diagnosis of duodenal ulcer was made following clinical and radiological investigation. He had been gassed during the war, otherwise the general health had always been good, and no morbid sign was present in the other systems.

Operation (Anæsthetic: chloroform and ether).—Transverse epigastric incision. A chronic peptic ulcer was present on the postero-superior aspect of the first part of the duodenum. There was a mucocele of the appendix. A gastro-duodenostomy was performed, and the appendix was removed. Next day the patient appeared distressed, the respiratory rate had increased to thirty per minute, and the pulse and temperature were elevated. Some cyanosis was present. The heart was displaced to the right, and dullness and diminished breath-sounds were present at the right base. On X-ray examination marked density was found over the lower half of the right lung, and the heart and mediastinal shadows were displaced to the right. Carbon-dioxide gas inhalations were administered, and brought about rapid improvement in the patient's condition. Respirations became deeper, the cyanosis disappeared, and the expectoration became more abundant. In two days the pulse and respirations had returned to normal, though dullness, coarse râles, and bronchial breathing were present in the chest. Complete return to normal, as seen in a radiogram, did not occur till the eleventh day after the operation. The patient was discharged from hospital on the twenty-first day after the operation.

Case 2.—Mrs. E. D., age 55 years. Patient had had digestive symptoms for thirty years. She was admitted to the Royal Infirmary, Edinburgh, four hours after perforation of a gastric ulcer.

Operation (Anæsthetic: chloroform and ether).—Right paramesial incision. A perforated gastric ulcer was present on the lesser curvature of the stomach. Free fluid was found in the peritoneal cavity. The perforation was closed and a glass suprapubic drain was inserted to the pouch of Douglas. Recovery was uneventful till the fifth day, when respiratory distress commenced, accompanied by cyanosis and elevation of temperature and pulse. The physical signs were: dullness at the left base, diminished breath-sounds, and movement of the heart to the left side. The diagnosis of massive collapse was confirmed by the radiogram, which demonstrated marked density of the left lower lobe of the lung and movement of the heart shadow to the affected side. With carbon-dioxide therapy relief was brought about in forty-eight hours, though physical signs in the lung persisted for nearly three weeks. The heart shadow remained slightly displaced for sixteen days after the onset of the condition.

Case 3.—F. R., female, age 13 years. Patient had two mild attacks of appendicitis during the preceding year. On the morning of admission to the Royal Infirmary, Edinburgh, she was seized with severe abdominal pain, which passed to the right iliac fossa. Superficial and deep tenderness were present over McBurney's point.

Operation (Anæsthetic: chloroform and ether).—Gridiron incision. The appendix was acutely inflamed and pelvic in position. The appendix was removed with drainage. Recovery was uneventful till the fifth day after operation, when the patient became slightly cyanosed and developed a cough. The left lung base was dull to percussion and breath-sounds were faintly bronchial in character. Radiological examination demonstrated massive collapse of the left side (*Figs.* 296, 297). Later the same day some sticky mucus was coughed up, and thereafter the breath-sounds became vesicular and crepitations were heard. No elevation of temperature occurred. Two days later the chest was clear, both on clinical and radiological examinations.

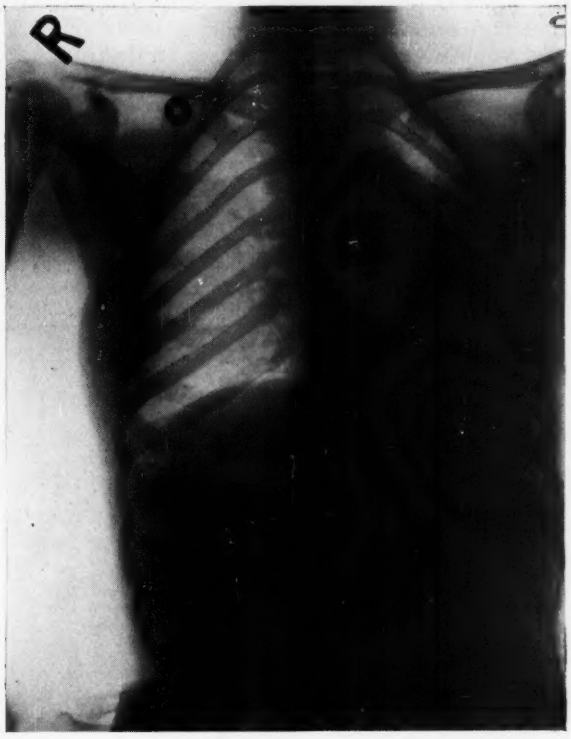

FIG. 296.—*Case* 3. Forty-eight hours after the onset of symptoms. Marked density throughout the greater part of the left lung. The heart is displaced to the left. The left half of the diaphragm is elevated.

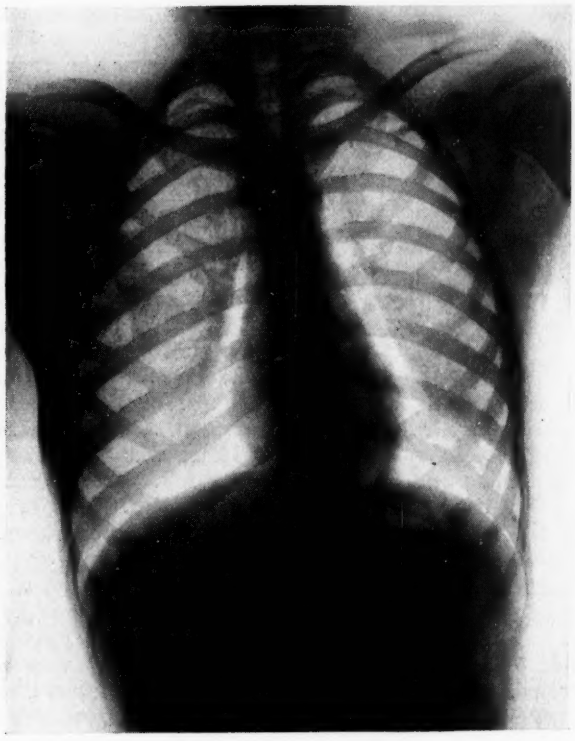

FIG. 297.—*Case* 3. Nine days after the onset of symptoms. The lung densities are equal and normal. The heart shadow has returned to its normal position. The diaphragmatic levels are equal.

Case 4.—G. S., male, age 22 years. Patient was a healthy young man who had suffered from intermittent attacks of abdominal pain associated with nausea and vomiting. Slight tenderness on deep palpation over McBurney's point persisted, and a diagnosis of chronic appendicitis was made.

Operation (Anæsthesia: chloroform and ether).—Battle's incision. The appendix was kinked and bound down by numerous adhesions and its wall was thickened. The appendix was removed. The following day the patient showed very marked signs of respiratory distress. Cyanosis was present, and there was elevation of pulse and temperature. Dullness was present over the greater part of the right lung, and breath-sounds were faintly bronchial in character. The cardiac dullness had moved to the right of the sternum. On radiological examination marked density was present throughout the lower two-thirds of the right lung, and the cardiac shadow was seen drawn over to the right (*Fig.* 298). The patient remained very distressed, cough was persistent and non-productive. Many coarse râles could be heard throughout the affected lung. On the third day after the development of the collapse the condition of the patient was very grave. Expectoration was very slight and coughing very ineffectual in getting rid of the bronchial secretion. Bronchoscopic aspiration of the retained mucopurulent secretion was carried out, after spraying the upper respiratory passages with cocaine. On passing the bronchoscope through the cords, the deviation of the trachea to the right became apparent by a slight bulging of the left tracheal wall. When the bronchoscope was passed down to the level of the carina this was found to the right of the midline of the visual field. The mouth of the right bronchus contained a considerable quantity of whitish secretion. About 10 c.c. of thick viscid secretion was removed from the right lung. Movement in the right lung could not be observed accurately owing to the amount of secretion lying in the bronchi, but movement was obviously diminished. There was immediate relief to the respiratory distress, and the pulse and temperature fell. The breath-sounds became bronchial in character, with finer accompanying râles. Recovery was complete in ten days following the bronchoscopic aspiration, and the chest was normal both in clinical and radiological examinations.

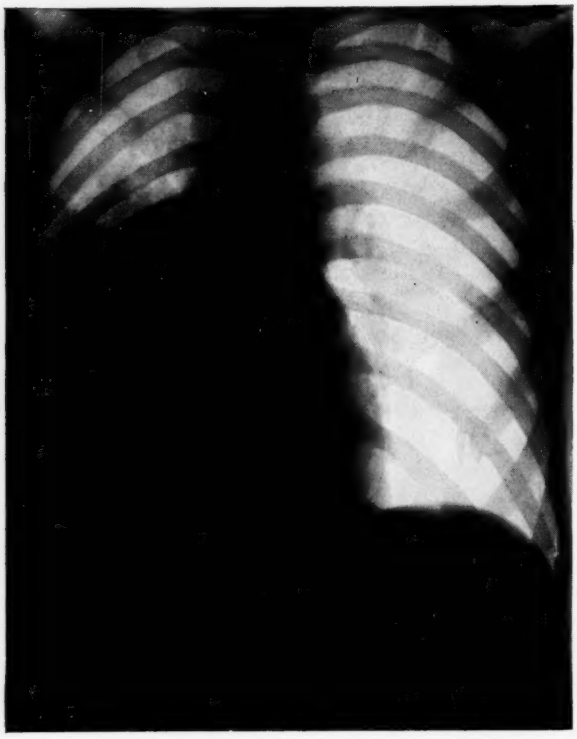

Fig. 298.—*Case* 4. Forty-eight hours after the onset of symptoms. Marked density of lower lobes of the right lung. Heart displaced to the right.

On bacteriological examination the sticky mucopurulent secretion aspirated was found to contain a heavy infection of pneumococci. The glutinous character of the material was particularly noticeable. Part of the secretion was laid aside for experimental injection; the remainder was tested against various dilutions of gum acacia, in order to get a measure of its viscosity. The viscosity of the secretion was estimated at 75 per cent by comparison with similar strengths of gum acacia.

After this experience it seemed appropriate to follow the example of Tucker and Lee, [22, 23, 35, 36] and try to produce what seemed to us the predisposing conditions under which we might expect the appearance of collapse. To do this we have used similar methods, utilizing gum solutions to simulate secretion in the bronchi.

THEORIES OF CAUSATION.

Theories of the origin of atelectasis fall roughly into four groups: (1) Those which postulate an active process in the lung, probably of reflex nervous origin; (2) Those in which posture is considered the most important point; (3) Those in which the essential is an absorption of air below an obstruction such as would be provided by a plug of mucus; (4) Diaphragmatic paralysis. Several writers put forward a combination of these possible causes and suggest various underlying states to account for them.

Pasteur[29] believed that atelectasis was due to an active contraction of the lung following the paralysis of the diaphragm, the contraction being of the nature of an imbalance between the contractile and expansile powers of the lung owing to the impairment of the latter by diaphragmatic failure. Elliott and Dingley,[13] however, very shortly afterwards pointed out that the arrangement of the lung musculature does not permit of this supposed action.

One of the most popular theories is that spasm or some vasomotor disturbance is at work. Scott,[32] Santee,[30] Leopold,[25] Scrimger,[33] Bergamini and Shepherd[3] all incline to the view that bronchial spasm is the underlying condition. Scrimger draws attention to the fact that the smooth muscle fibres in the bronchial walls are scanty, and he believes that they are insufficient to cause a complete collapse, and, that being so, he assumes that the presence of mucus is required to complete the mechanism. Santee, Bergamini, and Shepherd produce the most convincing arguments for some such mechanism in their quotations of four cases, with complete pathological reports of death at the time of operation, the cause being massive atelectasis.

Apart from this clinical evidence, and in passing, we may remark that we are not convinced, as the authors seem to be, that the obstructive theory is inapplicable; there is singularly little evidence that reflex irritation or spasm can produce anything resembling atelectasis—in fact, the experimental evidence goes far to negative the possibility. Opening the abdomen and traumatizing the viscera has never been observed to cause any spasm of the bronchi, and violent external stimuli seem to act by fixation of the muscles of respiration, and in this way interfere with the normal mechanism of the lung.

The work of Fontaine and Herrmann[16] on denervated lungs points to the fact that if there is any question of nervous stimulus, the cause is just as likely to be found in the lung itself as in the operation field. Again, we may refer to the fact that so far we have no record of cases of collapse of the lung in those conditions which we are accustomed to refer to as of nervous origin, namely, asthma and angioneurotic œdema. Indeed, these affections have been proved to cause the reverse condition, namely, emphysema, by virtue

of the intermittent spasm. As far as we are aware, there is no record of the production of tonic spasm of the bronchi either by clinical or experimental observation. We cannot help concluding, therefore, that there is no direct evidence that any condition of spasm or other vasomotor disturbance is produced in the lung which is concerned with the causation of massive atelectasis.

One of the most difficult classes of case to reconcile with the more favoured theories of causation is the traumatic type—for example, that following gunshot wounds of the chest. Sir John Rose Bradford[4] has given a very complete account of the atelectasis which accompanies a considerable percentage of all penetrating wounds of the chest. This writer mentions that urgent symptoms have always been absent in contralateral collapse, but also observes that no case of complete contralateral collapse has been seen. This seems to indicate a process of gradual onset, or one in which the symptoms are masked by the greater trauma of the wound, and it also lends support to Crymble's[10] observation that the wounded man tends to lie on the unwounded side, thus introducing the very definite factor of limitation of lung movement. Crymble further points out that the recovery of the collapse is independent of the processes in the opposite lung, meaning that, although the other lung becomes more involved by pathological processes, the recovery of the collapsed lung is not unduly retarded. Here again we have the condition differing apparently in pathology from the trauma it accompanies, and pointing to some factor which is coincident with the wound. Lilienthal makes the suggestion that the pathology of gunshot collapse differs from that of post-operative collapse, but it seems unnecessary to complicate the matter in this way, as the pathology itself has been determined by Lichtheim,[26] Coryllos and Birnbaum,[9] and others, the mechanism by which it is produced being the problem which requires solution.

Pursuing the subject of posture as a possible factor in the production of atelectasis, we find in Briscoe[5] a strong supporter of this theory, and he has worked out several different types of patient likely to develop atelectasis from the deflation of the lower lobes consequent on the posture adopted, the determining factor being crural disability from overlying pleurisy. The theory is interesting in that the ultimate mechanism is purely diminution of respiratory force. While it is feasible for certain cases, the chief objection seems to us to lie in its inapplicability to so many other types of case. The assumption of the presence of pleural inflammation in every individual suffering from this complication appears to us to be unwarranted.

In conclusion, one would like to refer to those cases which have been recorded as occurring after operation under spinal anæsthesia. These have been pointed out as disproving the fact that massive collapse is primarily due to lung interference. We think, however, that these cases are strongly in favour of the occurrence of some such mechanism as we describe, as will be seen if the technique of this particular form of anæsthesia is considered. Anæsthesia frequently reaches above the costal margin, and the intercostal muscles are out of action when the abdomen is opened. The consequence is that the diaphragm has to carry the whole burden of respiration. If the operation is upper-abdominal, there is considerable interference with the diaphragm by handling. If lower-abdominal, the probability is that some

degree of Trendelenburg position is used, thus causing further embarrassment of the diaphragm by the tendency of the viscera to move to the upper part of the abdominal cavity.

Thus we have the essential mechanical factor of serious embarrassment of respiratory mechanism.

EXPERIMENTAL INVESTIGATION.

Using dogs, an extensive series of operative procedures was carried out, individually and in combination, under narcosis. The series of experiments has been divided into nine groups, each of which introduced a variation in the operative procedure or in the technique employed. The effect on the respiratory tract was studied in each group, using clinical, bronchoscopic, and radiographic methods. In certain experiments the animal was killed, and the respiratory organs were examined at autopsy. The groups were made up as follows :—

Group

I.—Laparotomy.

II.—Bronchoscopy and bacteriological examination of normal dog's bronchus.

III.—Bronchoscopy and the introduction of gum acacia of varying degrees of viscosity to the right bronchus.

IV.—Bronchoscopic introduction of a solid foreign body to the lumen of the right bronchus.

V.—Laparotomy combined with bronchoscopic introduction of gum acacia to the lumen of the right bronchus.

VI.—Bronchoscopic introduction of gum acacia of low viscosity, followed by strapping of the chest.

VII.—Introduction of gum acacia of viscosity similar to specimen of bronchial content obtained from a patient suffering from massive collapse, followed by the application of adhesive strapping to the lower ribs.

VIII.—Exposure of the right phrenic nerve in the neck, study of the effect of electrical stimulation and avulsion of the nerve.

IX.—Bronchoscopic introduction of gum acacia in a previously phrenicectomized animal.

Narcosis was produced by the hypodermic injection of amytal and morphine two hours prior to the experiment. The dosage was calculated from the body weight of the animal. The anæsthesia obtained gave complete satisfaction for all operative procedures, and the cough reflex was abolished. The return to consciousness was complete in three to three and a half hours from the time of the injection, and no undesirable symptoms presented. By avoiding an inhalation anæsthetic, the intrabronchial secretion was under the control of the operators and bronchoscopic examinations were made with greater freedom. Massive collapse of the lung developed in *Groups VII* and *IX* in every case.

EXAMPLES FROM TYPICAL ANIMAL EXPERIMENTS.

Group I.—Laparotomy.

Dog, male, weight 10·45 kilos.

Preliminary X-ray examination of the chest revealed no abnormality. The lungs were of equal and normal density. Both halves of the diaphragm moved symmetrically.

Anæsthesia : open ether.

Abdomen opened by a paramesial incision through the right rectus muscle. The stomach, liver, and small intestine were handled and slightly traumatized. The wound was closed in layers with linen sutures.

In 24 hours : X-ray examination repeated. Lung fields of normal density, diaphragmatic movement normal and equal. Heart shadow undisplaced. No lobular collapse of the lung present. Recovery uneventful.

Group II.—**Bronchoscopy.**

Dog, male, weight 10·45 kilos.

Anæsthesia : amytal 6 c.c. ; morphine 1 gr. hypodermically, given two hours prior to experiment.

Bronchoscope passed. Bronchi inspected and found to be normal. Swabs taken from bronchial mucosa and from teeth for bacteriological examination. Movements of bronchial tubes during inspiration and expiration studied.

Lipiodol was injected through the bronchoscope. The animal was X-rayed and a normal photograph of the bronchial tree obtained.

Bacteriological Report.—Culture from swab from normal dog's bronchus yielded growths of a few streptococci, a few pneumococci. Culture of swab from healthy dog's teeth yielded growths of a few short strepto- and diplococci.

Group III.—**Bronchoscopy and the introduction of gum acacia of varying degrees of viscosity to the right bronchus.**

a. Dog, male, weight 11 kilos.

Anæsthesia : amytal 5·5 c.c. ; morphine 1 gr.

Bronchoscope passed, and 5 c.c. of 40 per cent gum acacia injected into the lumen of the right bronchus.

The animal showed no signs of distress and appeared quite normal twenty-four hours later. X-ray examination the following day revealed a few scattered areas of lobular collapse at the base of the right lung. There was no displacement of the heart.

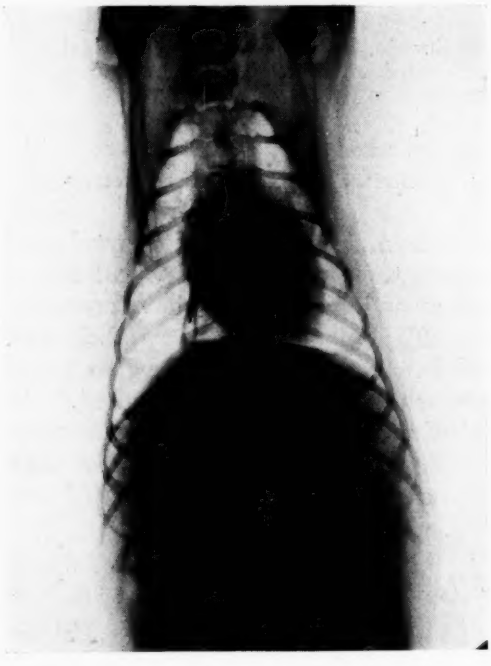

Fig. 299.—*Group IV.* The foreign body is in position in the right bronchus. Heart and lungs normal.

b. As in previous experiment.

Ten c.c. of 50 per cent gum acacia injected into the lumen of the right bronchus.

Result similar to that in previous experiment. A few areas of lobular collapse were noted.

Group IV.—**Bronchoscopic introduction of a solid foreign body to the lumen of the right bronchus.**

Dog, male, weight 11·4 kilos.

Anæsthesia : amytal 5·5 c.c. ; morphine 1 gr.

A solid portion of rubber reinforced by a U-spring was accurately fitted into the lumen of the right bronchus, to remain there securely after release of the spring. X-ray examination carried out shortly afterwards revealed the foreign-body plug to be in position (*Fig.* 299). On recovery from the anæsthetic the animal was active, and coughed considerably. Twenty-four hours later

X-ray examination revealed the foreign body in the animal's stomach. The lung was normal and the animal well.

Group V.—**Laparotomy combined with bronchoscopic introduction of gum acacia to the lumen of the right bronchus.**

a. Dog, male, weight 12 kilos.

Anæsthesia: amytal 6 c.c.; morphine 1 gr.

Bronchoscopic injection of 10 c.c. of 50 per cent gum acacia to the lumen of the right bronchus.

Laparotomy carried out immediately through a right rectus incision. The abdominal viscera were handled, and the wound closed in layers by linen sutures. A slight degree of dyspnœa was noted after operation. Twenty-four hours later the animal appeared normal. On X-ray examination scattered areas of lobular collapse were present in the right lung.

b. Dog, male, weight 11·3 kilos.

Anæsthesia: amytal 5·5 c.c.; morphine 1 gr.

Laparotomy carried out as in previous experiment. Bronchoscopic introduction of 15 c.c. of 75 per cent gum acacia to the lumen of the right bronchus. The animal became dyspnœic and remained with signs of respiratory distress for three hours after the experiment. Twenty-four hours later the animal appeared normal. On X-ray examination there was a considerable number of scattered areas of lobular collapse in the right lung. There was no deviation of the heart or the mediastinum.

Group VI.—**Bronchoscopic introduction of gum acacia of low viscosity, followed by strapping of the chest.**

Dog, male, weight 11 kilos.

Anæsthesia: amytal 6 c.c.; morphine 1 gr.

Six c.c. of 40 per cent gum acacia were introduced to the lumen of the right bronchus. A band of adhesive strapping was applied round the lower ribs.

Twenty-four hours later X-ray examination revealed considerable lobular collapse in the right lung, but no deviation of the heart.

Experiment: Bronchoscopic Introduction of Bronchial Contents from a Patient suffering from Post-operative Massive Collapse of the Lung.

Dog, female, weight 7·4 kilos.

Anæsthesia: amytal 4·5 c.c.; morphine 1 gr.

Following introduction of the bronchoscope, 3 c.c. of the bronchial content, which had been preserved with aseptic precautions, were injected into the lumen of the right bronchus. In ten minutes it was noted that there was a slight increase in the respiration rate in the animal, but thirty minutes later a return had been made to normal. Fifteen hours later animal found dead.

Post-mortem Report.—Generalized bronchopneumonia was present. A pure growth of pneumococci was obtained from bacteriological examination of uncontaminated lung tissue.

Group VII.—**Introduction of gum acacia of viscosity similar to specimen of bronchial content obtained from patient suffering from massive collapse, followed by the application of adhesive strapping to the lower ribs.**

a. Dog, male, weight 12 kilos.

Anæsthesia: amytal 6 c.c.; morphine 1 gr.

Bronchoscope introduced and the injection of 75 per cent gum acacia continued until the lumen of the right bronchus was filled, 30 c.c. in all. A strip of adhesive strapping was then applied to the lower ribs.

In 3 hours: slight increase in density of right lung, associated with some displacement of the heart to the right.

In 24 hours: complete and marked density throughout right lung. Heart and mediastinum displaced to the right. The right half of the diaphragm is elevated. The animal is restless and inclined to be savage. (*Fig.* 300.)

FIG. 300.—*Group VII* (Dog *a*). Twenty-four hours. Complete density throughout right lung. Heart and mediastinum displaced to the right. Right half of the diaphragm elevated. Intrabronchial gum acacia and strapping of the chest.

FIG. 301.—*Group VII* (Dog *a*). Forty-eight hours. Marked density of right lung. Heart displaced to right.

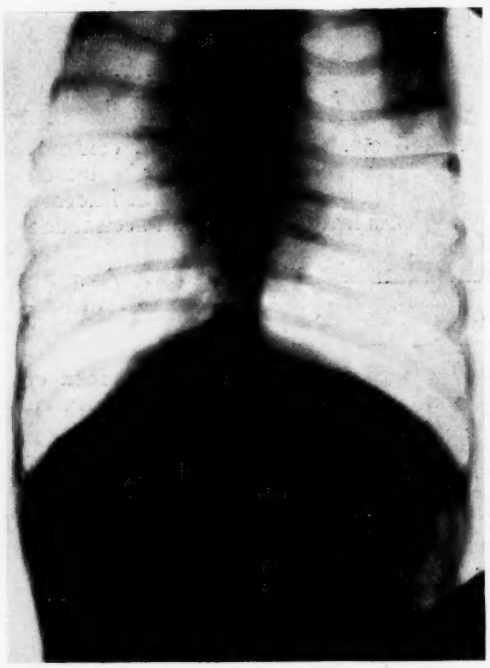

FIG. 302.—*Group VII* (Dog *a*). Ten days. The heart is normal in position. The lung is clear except for one or two areas of lobular collapse.

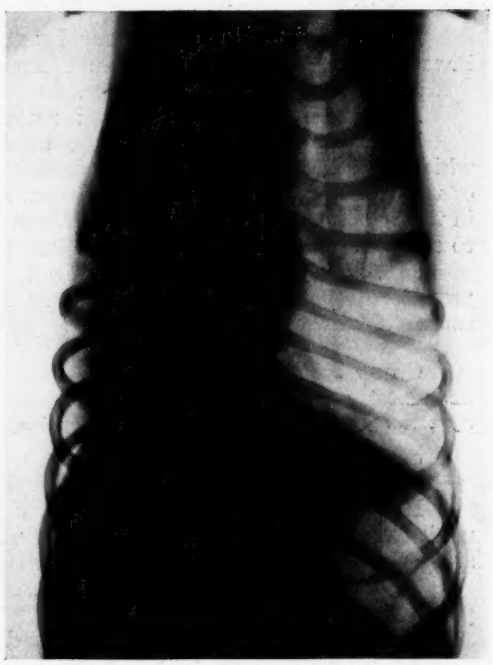

FIG. 303.—*Group VII* (Dog *b*). Twenty-four hours. Complete density through right lung. Heart and mediastinum displaced to right. Right half of diaphragm elevated. Intrabronchial gum acacia, and strapping of the chest.

In 48 hours: marked density throughout the right lung. Heart displaced. (*Fig.* 301.)

In 4 days: upper and middle lobes still dense. Lower lobe clearing. Heart still displaced and diaphragm elevated.

In 8 days: heart shadow has almost returned to normal position. Lower part of lung clearing rapidly. There are still scattered areas of increased density. Diaphragm functioning.

In 10 days: heart normal in position; still slight lobular collapse in lung. (*Fig.* 302.)

b. Dog, male, weight 10·5 kilos.

Anæsthesia: amytal 5 c.c.; morphine 1 gr.

As in previous experiment. Introduction of bronchoscope and injection of 20 c.c. 75 per cent gum acacia into right bronchus. A strip of adhesive strapping was applied to the lower ribs. Early dyspnœa. X-ray examination.

FIG. 304.—*Group VII* (Dog *b*). Six days. The density over the right lung is clearing irregularly. The right half of the diaphragm is still elevated. The heart has not yet returned to its normal position.

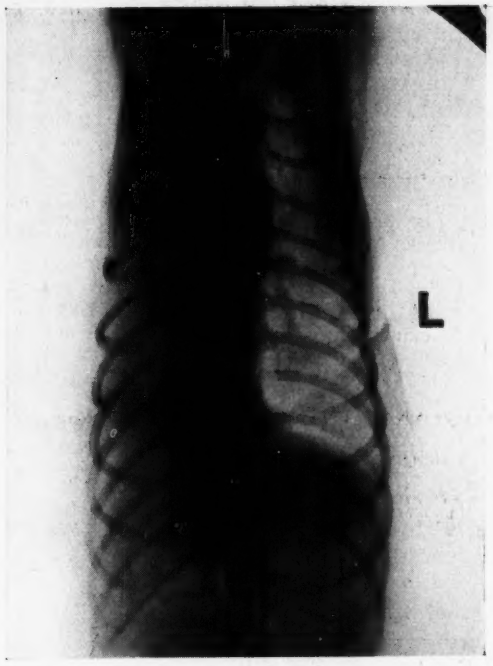

FIG. 305.—*Group VII* (Dog *c*). Complete density throughout right lung. Displacement of the heart to the right. Elevation of right half of the diaphragm. The animal was killed at this stage. Intrabronchial gum acacia and strapping of the chest.

In 24 hours: displacement of heart to the right; marked density over whole of right lung; right half of diaphragm elevated. (*Fig.* 303.)

In 3 days: heart shadow has returned slightly in normal direction. Marked and persistent density over whole of right lung.

In 6 days: density over right lung is clearing irregularly. The diaphragm is still elevated. The heart has not yet returned to its normal position. (*Fig.* 304.)

In 11 days: heart and diaphragm normal in position and appearance. Lung clear except for one or two slight areas of lobular collapse.

c. Dog, female, weight 9·4 kilos.

Anæsthesia: amytal 5 c.c.; morphine 1 gr.

Bronchoscopic introduction of 20 c.c. of 75 per cent gum acacia to right bronchus. Application of strapping to lower ribs. X-ray examination.

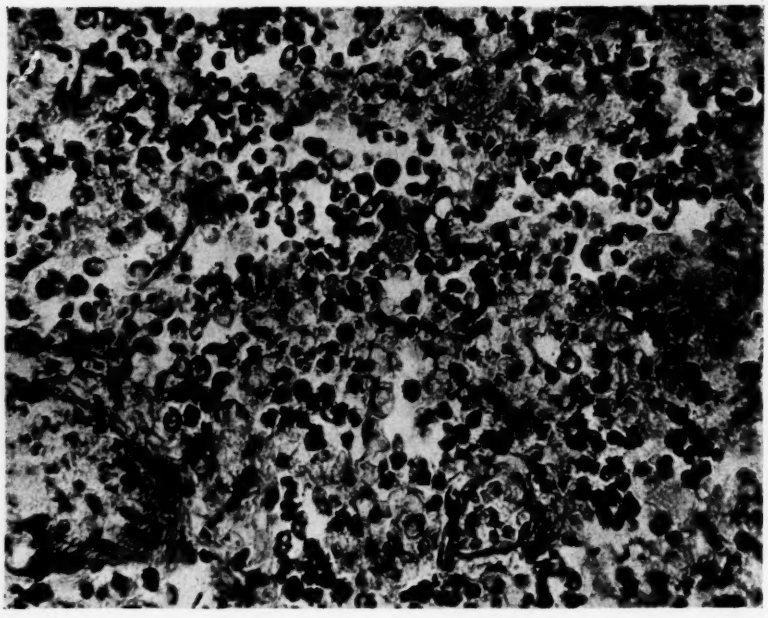

FIG. 306.—*Group VII* (Dog *c*). Section of right lung twenty-four hours after induction of collapse. The alveoli are collapsed, the lining cells are œdematous, and a hæmorrhagic exudate has occurred. The vessels are greatly dilated.

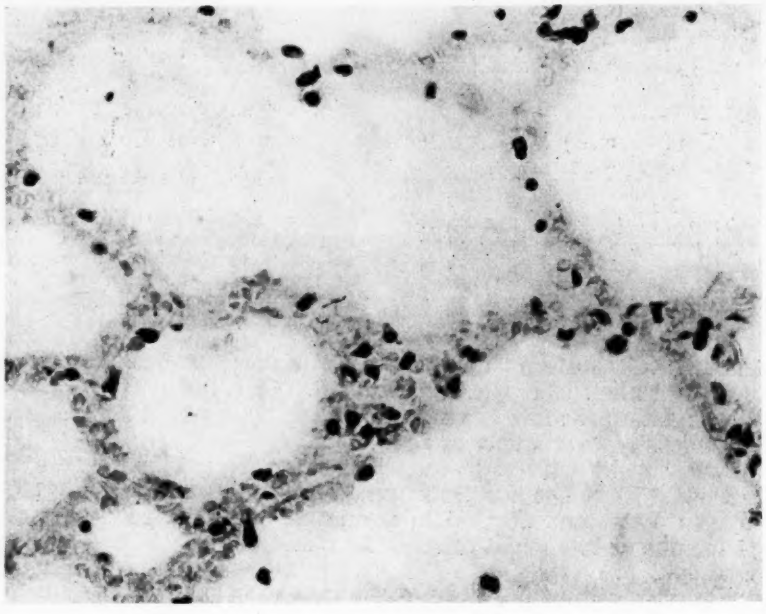

FIG. 307.—*Group VII* (Dog *c*). Section of normal left lung.

In 24 hours: complete density over right lung, displacement of heart to the right, elevation of diaphragm. (*Fig.* 305.)

The animal was killed with chloroform and autopsy at once carried out. The right lung was found to be smaller than normal, darkly congested, without normal crepitus, and heavier than water. The left lung was normal in all respects.

Sections were cut for histological study. These demonstrated alveolar collapse throughout the affected lung; there was in addition considerable congestion. Dilatation of the vessels was present and a hæmorrhagic exudate had occurred throughout. (*Figs.* 306, 307.)

In this group massive collapse of the lung was experimentally produced in every case.

Group VIII.—**Right phrenic nerve exposed in the neck and divided, electrical stimulation, and later avulsion of the distal end carried out.**

Dog, female, weight 9 kilos.

Anæsthesia: amytal 5 c.c.; morphine 1 gr.; open ether.

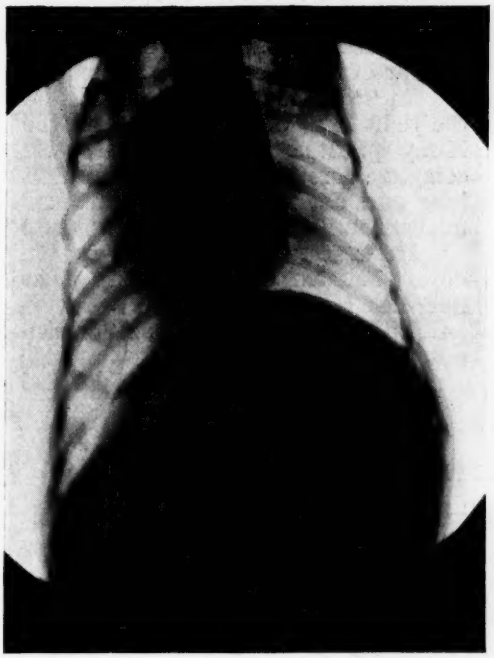

FIG. 308.—*Group VIII.* Effect of electrical stimulation of right phrenic nerve. The right half of the diaphragm is in contraction.

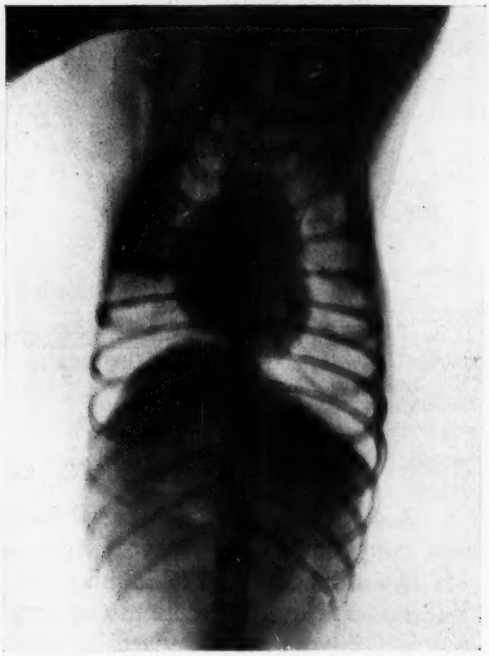

FIG. 309.—*Group VIII.* Effect of avulsion of the right phrenic nerve. The right half of the diaphragm is elevated and paralysed.

Oblique incision made in the neck; cervical nerves and phrenic nerve exposed and isolated, right phrenic nerve secured and divided. Effect of electrical stimulation and avulsion studied under screen examination.

X ray.—Phrenic-nerve stimulation produced sudden spasm of the diaphragm and fixation of the lower ribs. Excessive stimulation brought about a convulsive spasm of the thorax in addition. During mild stimulation the diaphragm was seen to be in spasm and fixed in full contraction, the lower rib interspaces were narrowed. The heart appeared to have deviated to the right. (*Fig.* 308.)

The phrenic nerve was avulsed, slowly and completely. The wound was closed with linen sutures. Subsequent radiological examination revealed cessation of movements and elevation of the right half of the diaphragm. The mediastinum was normal. (*Fig.* 309.)

***Group IX.*—Avulsion of phrenic nerve and production of paresis of one half of the diaphragm, followed by the bronchoscopic introduction of gum acacia.**

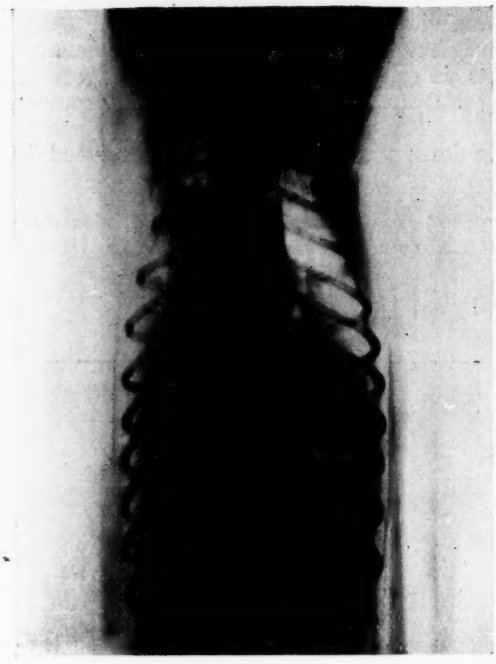

FIG. 310.—*Group IX.* Complete density of lower half of the right lung. Displacement of the heart to the right. Intrabronchial gum acacia and phrenic neurectomy.

Dog, male, weight 9·4 kilos.

Anæsthesia: amytal 5 c.c.; morphine 1 gr.; open ether.

Avulsion of right phrenic nerve carried out as in previous experiment. Paresis of the right half of the diaphragm was confirmed by X-ray examination.

One Month Later. Anæsthesia: amytal and morphine.

Bronchoscope passed and 15 c.c. of 75 per cent gum acacia introduced to the lumen of the right bronchus, when it was occluded. Twenty minutes later some dyspnœa was observed, and on screen examination an increase in the density of the lung shadow of the affected side was noted.

In 24 hours: massive collapse of the right lung was observed, and the X-ray photograph was typical, with complete density throughout the right lung and deviation of the heart and mediastinum to the right. (*Fig.* 310.)

Resolution was complete in ten days. Massive collapse of the right lung had been produced.

The experiments were also carried out in animals on which the left side was similarly dealt with. Identical results were obtained.

RESULTS OF EXPERIMENTS.

A solid foreign body placed in the lumen of the bronchus under narcosis was coughed up on recovery from the anæsthesia (*Group IV*). In *Groups III, V*, and *VI* areas of lobular collapse were found in the lung. In *Groups VII* and *IX* massive collapse of the lung was produced. In *Group VII* gum acacia (75 per cent), of viscosity similar to that of the intrabronchial secretion from a patient suffering from massive collapse of the lung, was introduced to the right bronchus of a narcotized dog. The procedure was followed by the application of strapping to the lower ribs of the animal. In *Group IX* a previously phrenicectomized animal was taken. Gum acacia of the same viscosity as in *Group VII* was introduced to the bronchus of the phrenicectomized side, under narcosis.

It will be seen that three factors, acting in combination, were necessary for the experimental production of massive collapse of the lung, namely: (1) *Intrabronchial content of definite viscosity*; (2) *Abolition of the cough reflex*; (3) *Limitation of respiratory movement.*

1. **Viscosity of Intrabronchial Content.**—It was found that the more fluid types of intrabronchial content, i.e., under 70 per cent gum acacia, were expressed proximally and expelled after the return of the cough reflex. No

interference with respiratory function occurred, and at most scattered areas of lobular collapse were seen in the radiogram of the chest. A solid foreign body plugging the bronchus was always expelled on the return of the cough reflex, after expulsion rapid aeration of the lung followed, and no areas of collapse were seen on the radiogram fifteen hours later. The means by which there was obtained a gum acacia solution of viscosity similar to the secretion in the human bronchus in a case of massive collapse, has been described. The estimation of 75 per cent gum acacia strength was arrived at by comparison in test-tubes. On studying the effect of the introduction of 75 per cent gum acacia with the bronchoscope, it is seen that the viscous material clings to the wall of the bronchus. There is a slight to-and-fro movement with inspiration and expiration. As the bronchus dilates with inspiration, however, the gum moves distally farther down the lumen. Soon, as the diameter of the lumen of the bronchus diminishes, partial and finally complete obstruction occurs. As one writer has put it: "the secretion agglutinates to obstruct".

2. **Abolition of the Cough Reflex.**—The use of morphine as an adjuvant to amytal anæsthesia was particularly valuable. The cough reflex remained inactive during the intrabronchial manipulations provided these were carried out gently and without trauma to the mucosa. At the end of the experiment the animal remained more or less asleep in its cage for an hour or two, and no effectual spasm of coughing took place. Later the animal moved about and drank water. Vomiting did not occur. If effectual coughing did take place following traumatization, the gum acacia was expelled, the air-passages were cleared, and the lung became fully aerated. Persistent deep narcosis was found to be unnecessary both for the intrabronchial or intra-abdominal manipulations, provided these were carried out gently.

3. **Limitation of Respiratory Movement.**—In *Group VII* this was produced by the application of adhesive strapping to the lowest ribs on one side. The tension was similar to that sometimes used when securing an upper abdominal dressing and less than that for fractured ribs. The strapping was applied over the hairy coat, to allow a fair margin of movement with respiration. In *Group IX* limitation of respiratory movement had been brought about some weeks previously by avulsion of the phrenic nerve on one side. The subsequent paralysis of one half of the diaphragm was always confirmed by radiographic examination. In phrenicectomized animals no further measures to limit respiratory movement were taken, and no strapping was applied to the chest after the introduction of the gum acacia to the bronchus. It was found that in these animals a paramedian epigastric laparotomy incision, made and closed under aseptic surgical conditions, produced no limitation of respiratory movement. Complete aeration of the lung bases was confirmed by radiographic examination. The animals moved about in their cages with apparent freedom on the night of operation, and in none of the experiments was laparotomy a causative factor in the production of massive collapse of the lung.

APPLICATION OF EXPERIMENTAL FINDINGS TO SURGICAL PRACTICE.

Under this heading the question must be asked: Are these three factors —(1) viscid intrabronchial content, (2) abolition of cough reflex, (3) limitation

of respiratory movement—present in the post-operative period in surgical practice? If they are, then a certain incidence of post-operative collapse of the lung is to be expected.

1. **Viscid Intrabronchial Content.**—The 'wet' anæsthetic is too well known to warrant further description. The bronchial hypersecretion may have accompanied a temporary or chronic bronchial catarrh, or it may be due to the action of irritant anæsthetic vapour on a sensitive mucous membrane. Cigarette-smoking has been blamed as an etiological factor. Asthmatics, as a rule good subjects for careful inhalation anæsthesia, have also been mentioned. The frothy hypersecretion of the typical 'wet' anæsthesia is probably of less importance in the etiology of massive collapse than the more viscid type of secretion obtained in much smaller quantity from those patients in whom chronic irritation has produced a more patchy type of reaction in the respiratory passages. To this group smokers and asthmatics belong.

2. **Abolition of Cough Reflex.**—The cough reflex is abolished in every inhalation anæsthesia. In most cases operated on under local or spinal anæsthesia a preliminary sedative or narcotic is given. The intrabronchial content is subject mainly to the rhythmic movements of the bronchial tube alone. It is known that an intrabronchial content above a certain viscosity tends to be indrawn to the smaller branches of the bronchial tree. The right bronchus offers a more direct route to the descent of such retained secretion. In the immediate post-operative period it is customary to administer morphine or its derivatives, to allay pain. The sedative action of morphine on the respiratory centre and the cough reflex is well known. Later the pain in the wound produced by coughing is such that the conscious patient voluntarily tries to avoid any spasmodic respiratory effort such as coughing, sneezing, or laughing.

3. **Limitation of Respiratory Movement.**—Quiet regular breathing is demanded from his anæsthetist by every surgeon. No deficiency in aeration of the lung should occur, however, unless the presence of intra-abdominal packs, or the operative position of the patient, should unavoidably interfere to some extent with the descent of the diaphragm or rib excursion. In such cases the lung bases alone are deficiently aerated. The application of over-tight bandages, especially when such bandages extend over the costal margin, is a potent factor in limiting post-operative movement of the abdomen and ribs during respiration. The narcotized respiratory centre maintains breathing of a shallow type only. Aeration of the lung bases is considerably impaired. Secondary factors of posture and flatulent distension are also of importance. The supine patient does not have the aid of gravity in the descent of the liver during inspiration. Similarly the patient placed in an exaggerated Fowler's position, hunched forwards, has no facility to expand the lower ribs, and gravity brings the liver no farther than against the posterior abdominal wall.

The effect of operation on the vital capacity during the post-operative period was studied by Head,[18] whose results are :—

Operations on lower abdomen	..	..	30–40 per cent dim. V.C.
,, ,, upper abdomen	..	..	78–88 per cent ,, ,,
,, ,, thorax wall	..	..	14–34 per cent ,, ,,

Particular stress was laid on the subsequent limitation in the descent of the diaphragm, and the frequent subsequent development of small scattered areas of lobular collapse in the lung. This inability of the normal post-operative patient completely to aerate his lungs is complementary to his fear of movement, and to his helplessness in the presence of pain, real or anticipated.

In our experience with the experimental animal the experiments involving introduction of a bronchial plug and laparotomy failed to produce collapse, largely owing to the tendency of the animal to struggle to its legs and move about in its cell immediately on waking up from its anæsthetic. The post-operative efficiency of aeration of the lungs must have been raised beyond comparison with that of the human subject.

In addition to involuntary splinting of the abdominal muscles after operation, the plain muscle of the intestine remains quiescent and peristalsis is in abeyance. The effect of flatulent distension in limiting diaphragmatic descent is well known. It is also likely, however, that some diminution of diaphragmatic activity is reflex, initiated from its association with peritoneum which has established a control of all movement likely to be nocuous to itself or its contents.

THE PATHOLOGICAL PROCESS.

A few pneumococci and certain streptococci may be isolated from the healthy human bronchus. Similarly in the healthy dog limited numbers of pneumococci and streptococci may be isolated from the bronchial mucosa. The bronchial secretion from a patient suffering from massive pulmonary atelectasis was found to be heavily infected with pneumococci, and when some of it was placed in the bronchus of a healthy animal, a rapidly fatal and widespread bronchopneumonia at once developed. When massive collapse is experimentally produced in an animal and the animal is killed within twenty-four hours, the appearances in the lung post mortem are entirely those of collapse. The lung is heavy and darkly congested; it is no longer crepitant. The size is only slightly less than normal. Microscopically the alveoli are found to be collapsed. The lining cells are œdematous, the vessels are congested, and many red blood-corpuscles are lying both in the alveoli and in the stroma (*see Fig.* 306). The exudation containing blood-cells is a physical reaction following the absorption of air from the alveoli and the subsequent diminution in the intra-alveolar pressure. When massive collapse has been of longer duration before death occurs, the appearances post mortem become those of bronchopneumonia. This is the result of infection from the retained bronchial secretion which forms a culture medium for the pneumococci originally present. The œdematous and collapsed peribronchial alveoli become heavily infected, and both bronchioles and alveoli are occupied by a purulent exudate. Death from massive collapse of the lung *per se* rarely occurs before the morbid appearances of bronchopneumonia have become established.

A complete recovery, clinical and physical, is the rule in the majority of these cases. Probably because of this, there has been a tendency to underestimate the importance of atelectasis as the origin of serious ill health in a minor group. The case mortality of a post-operative pulmonary complication

has been estimated at 20 per cent. If, however, cases are included which suffer from transient pulmonary symptoms only and in which the diagnosis of pulmonary collapse is only made on a presumptive clinical basis or after radiological examination, the total number of post-operative pulmonary complications will be considerably raised and the case mortality will fall. The pathological conditions found in the lung as late results of incompletely resolved atelectasis are bronchiectasis and pulmonary abscess. The clinical signs which interpret the development of these conditions in a case of unresolving massive collapse are very variable. The radiological appearances, however, show that the mediastinum and heart shadows do not return so completely to their normal position, and areas of increased density remain at the site of collapse.

THE PREVENTION OF POST-OPERATIVE PULMONARY ATELECTASIS.

Having regard to the combination of factors which predispose to the experimental production of massive collapse, the prevention of this post-operative condition will probably be most successful where co-operative measures are undertaken by the members of a surgical unit. Where possible, bronchial catarrh and oral sepsis should be corrected prior to operation. The choice of anæsthetic is important. Pre-operative atropinization of the patient is very valuable, but the use of atropine combined with heroin or morphine has the dangers associated with depression of the respiratory centre. To calm a patient prior to operation and to allay mental stress without acting as a depressant, no drug has proved more useful clinically than nembutal, which has been found safe and efficient with spinal, local, or general anæsthesia. The prevention of asphyxia and the prevention of accumulations of mucus in the respiratory passages are obvious measures to which the anæsthetist attends. The anæsthetist also has added carbon-dioxide gas to his armamentarium, by the use of which the respirations may be kept at sufficient depth, and the lung bases are preserved in a fully aerated state. At the end of operations which, by their nature, have produced some limitation of respiratory movement, full aeration may be re-established by the judicious use of carbon dioxide in the anæsthetic vapour.

Dressings should be secured in such a manner that they in no way interfere with respiratory movement. Such bandages, etc., may be adjusted or loosened from time to time if any tightness is apparent. In the same way the position of the patient may be altered to ensure full diaphragmatic excursion. The firm canvas bed-rest is probably the most efficient means of procuring a comfortable reclining Fowler's position with maximum aeration of the lung bases.

Sedative drugs which have a strong affinity for the respiratory centre should be withheld until the patient has regained full consciousness. In the immediate post-operative period a spasm of coughing or the retching of post-anæsthetic sickness leads to the expulsion of retained intrabronchial secretion and thorough aeration of the bronchial tree. The early administration of morphine or heroin may permit such secretion to remain in the bronchus, agglutinating to obstruct.

The early recognition of flatulent distension and its treatment by procuring the passage of flatus will help to diminish the incidence of the delayed type of pulmonary lobular collapse.

TREATMENT.

The treatment of cases of post-operative massive collapse of the lung was until recently the routine treatment administered to cases of respiratory infections as a whole. There were advised poultices to the chest wall, medical diathermy, expectorant mixtures, steam tents, various antisera and vaccines.

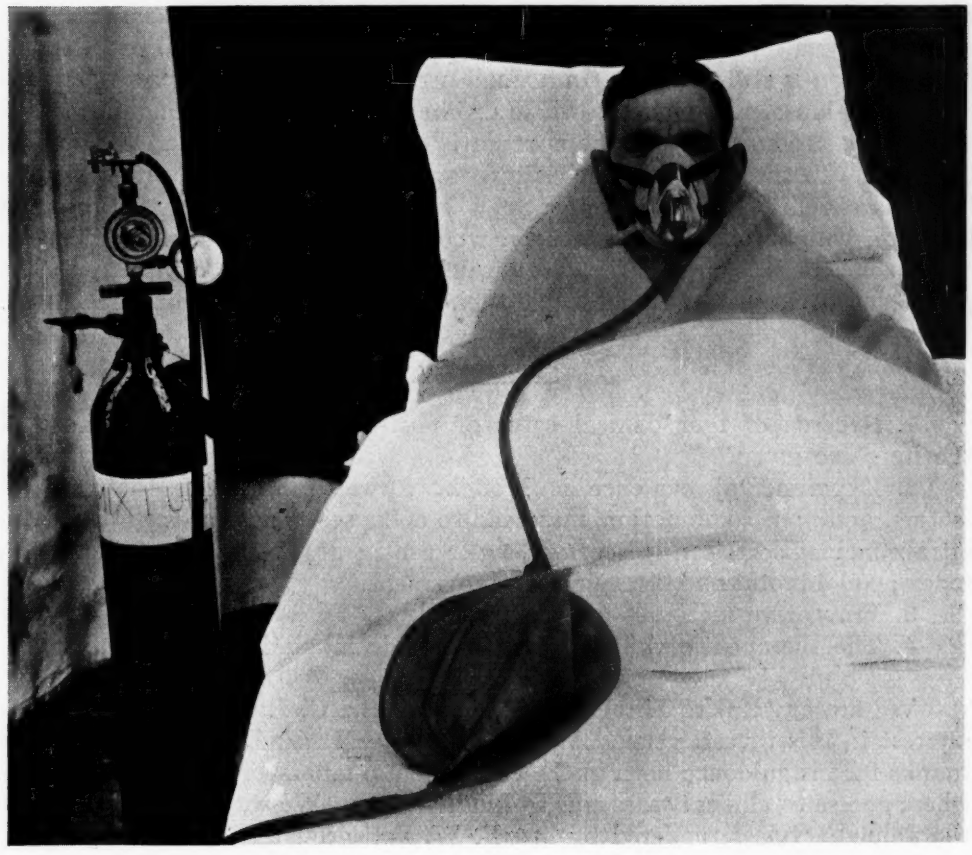

FIG. 311.—Carbon-dioxide therapy. CO_2 is being administered through a Haldane's mask inhaler.

Undoubtedly these were all helpful measures, particularly when bronchopneumonia had become established and the cough was productive of a purulent sputum. Associated infection of the pleura required symptomatic relief. Having regard, however, to one of the main factors in the etiology of massive collapse—shallow breathing—*carbon-dioxide gas becomes an important remedial measure.*

Carbon dioxide is supplied from a cylinder containing 10 per cent of the

gas in oxygen. The gas may be supplied direct to the patient from the cylinder through a length of tubing and a mask inhaler (*Fig.* 311), or a bag may be interposed to act as a reservoir. Carbon-dioxide-mixture inhalations are administered for ten minutes in every hour. The increased respiratory depth and the productive cough that follow give the patient very rapid relief. The frequent, short, non-productive coughs which interfere with sleep are abolished in the intervals between inhalations. On clinical examination of areas in the chest in which breath-sounds were absent on auscultation, vesicular breathing is found to have returned; the accompanying râles indicate the mobilization of secretion and the re-aeration of the alveoli. In early cases of pulmonary collapse complete recovery may be brought about in forty-eight to seventy-two hours. In more established cases there is complete symptomatic relief in that period, though radiological evidence of the condition is still present. In a small percentage of cases of post-operative massive collapse, in which the whole of one lung is affected, coughing is not sufficiently productive, and the sputum is small in quantity and difficult to bring up. In these cases bronchoscopic aspiration of the sticky mucus gives immediate relief, and the danger of a severe infection from the retained secretion will be avoided. Similarly, where radiological or clinical evidence of bronchiectasis is present in cases which fail to clear up completely after pulmonary atelectasis, bronchoscopic aspiration is a valuable aid to treatment.

SUMMARY.

1. Records of four clinical cases of post-operative massive collapse of the lung are given.

2. Experimental evidence is brought forward indicating that certain factors, acting in combination, may lead to collapse. These are: (*a*) A viscid intrabronchial secretion (viscosity 75 per cent); (*b*) Abolition of the cough reflex; (*c*) Limitation of respiratory movement.

3. Preventive measures are suggested.

4. The therapeutic value of carbon-dioxide inhalations is emphasized.

We are grateful to Mr. Henry Wade and Dr. G. Ewart Martin for their interest in this investigation. We owe Professor D. P. D. Wilkie our sincere thanks for his guidance both in the experimental laboratory and in the wards, where access to clinical cases was so kindly given. We would like to mention the valued services rendered by Mr. F. W. Pettigrew and the technical staff of the Surgical Research Department, University of Edinburgh. The expenses of this research were covered by a grant from the Earl of Moray Fund, University of Edinburgh.

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AN ANALYSIS OF 2126 CASES OF ACUTE APPENDICITIS.

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In the following tables an analysis has been made of the results of treatment of acute appendicitis at St. Thomas's Hospital during the years 1920–9 inclusive. This is of particular interest, as a similar investigation[1] carried out for the years 1894–1903 inclusive allows a comparison to be made between present results and those of thirty years ago. For this purpose the same grouping of the cases has been adopted.

We have endeavoured to include only those cases in which definite acute inflammation of the appendix was found at operation, or—if no operation were undertaken—those in which the history and clinical examination left little doubt as to the diagnosis. The classification into the following groups was made on the pre-operative clinical signs, rather than on the operative findings, because we consider that the presence of a palpable mass has a bearing of the greatest importance upon the line of treatment.

Table I contains the cases of acute appendicitis admitted during the first four days of the disease in which the inflammatory process was limited to the appendix or a localized peritonitis had occurred.

It is an established fact that appendicectomy carried out during the first twenty-four hours from the onset of the disease carries a very low mortality-rate—in our series 0·22 per cent. On subsequent days it rises to a much higher figure, but in this group does not continue to rise after the first forty-eight hours. The probable reason for this is the varying rapidity in the progress of the disease. It is noticeable, however, that the complication-rate appears to rise steadily, in direct relation to the time which elapses before operation.

There were a few cases, diagnosed as acute appendicitis and admitted during the first four days, which were not operated upon. These showed a much higher mortality- and complication-rate, although they appeared to be suffering from milder attacks.

Table II contains the cases of appendicitis with diffuse peritonitis admitted during the first four days of the disease, and immediate operation with removal of the appendix would appear to be the only rational form of treatment to adopt. Four cases treated only by drainage died; of five cases in which no operation was undertaken, four died: the fifth was considered too ill for surgical treatment, but recovered.

If appendicectomy is carried out, drainage of the peritoneum seems of little importance.

It is interesting to note there is little relation between the duration of

Table I.—Acute Appendicitis without Diffuse Peritonitis (1408 Cases).

A. Immediate Operation (1340 *Cases*).

Day of Illness	No. of Cases	Mortality		Complications	
		Cases	Per cent	Cases	Per cent
1st	442	1	0·22	7	1·58
2nd	531	17	3·20	27	5·08
3rd..	293	3	1·02	34	11·60
4th..	74	2	2·70	6	8·10
Totals ..	1340	23	1·71	74	5·50

B. Analysis of Complications (74 *Cases*).

Complicated by	1st Day	2nd Day	3rd Day	4th Day
Residual abscess*	5	12	22	3
Subphrenic abscess..	1	2	2	2
Obstruction	1	3	3	—
General peritonitis..	—	3	2	1
Pleural effusion	—	1	1	—
Pulmonary embolism	—	1	—	—
Femoral thrombosis	—	3	—	—
Portal pyæmia	—	2	1	—
Empyema	—	—	1	—
Septicæmia	—	—	1	—
Fæcal fistula	—	—	1	—
Totals	7	27	34	6

* *Note.*—Residual abscess occurred in 4 cases in which a drain was used, and in 33 cases in which the wound was closed without drainage.

C.—Summary of Cases of Acute Appendicitis admitted on First Four Days of Illness, which were not Operated upon (68 *Cases*).

Day of Illness	Discharged: Nothing further known	Discharged: Removal later	Went Wrong
1st ..	0	1	0
2nd ..	3	6	3 developed abscess
3rd ..	7	11	5 developed abscess: 1 died, 2 had acute attack a month later
4th ..	10	13	1 developed abscess; 1 died unoperated; 1 died after operation 2 days later; 6 developed acute attack, necessitating operation at intervals of 1, 3, 9, and 12 weeks respectively.
Totals	20	31	17

More than 25 per cent go wrong, and 4·4 per cent die.

the disease and the death-rate, which is as high on the first day as on any of the others.

Table II.—231 Cases admitted with Diffuse Peritonitis.

Day of Illness	Appendicectomy and Closure		Appendicectomy and Drainage		Drainage Only		No Operation	
	Recovered	Died	Recovered	Died	Recovered	Died	Recovered	Died
1st	9	3	5	0	—	—	—	—
2nd	32	7	22	6	—	—	—	—
3rd	37	10	38	8	—	3	—	3
4th	17	5	18	5	—	1	1	1
Totals ..	95	25	83	19	—	4	1	4

Mortality { Appendicectomy and closure = 20·8 per cent
Appendicectomy and drainage = 18·6 per cent.

Complications in Diffuse Peritonitis Cases (37 Cases).

Complicated by	2nd Day	3rd Day	4th Day
Fæcal fistula	1	1	—
Pleural effusion	1	—	—
Residual abscess	5	13	2
Pulmonary embolism	1	—	—
Subphrenic abscess	1	2	—
Femoral thrombosis	—	1	—
Obstruction	—	3	1
Empyema	—	2	1
Abortion	—	2	—
Totals	9	24	4

Conclusion.—In cases with diffuse peritonitis operated upon in the first four days, the death-rate is 20 per cent, and the percentage of complications is 20·6 per cent.

Table III contains the cases of appendicitis in which a localized mass could be felt at the time of admission. It is in this group that most discussion arises as to the correct treatment to be adopted. It has been the practice in this hospital to follow a conservative course where possible; but if the urgency of the symptoms makes operative interference essential, drainage alone is the method of choice. In some instances, however, where there is evidence of spreading infection of the peritoneal cavity, appendicectomy and drainage is performed, as this type of case is comparable to those in Group II.

Although this conservative method of treatment necessitates readmission for appendicectomy after a suitable interval, it is found in practice to involve little or no added risk. Of such cases, 299 were operated upon, with no deaths.

It is often stated that the adoption of any form of conservative treatment for acute appendicitis leads to an increase in the general mortality of

Table III.—487 Cases admitted with Palpable Mass.

Day of Illness	Operation					No Operation				
	Appendicectomy and Drainage		Drainage Only			Subsided		Evacuated by Bowel		
	Discharged	Died	Discharged: Nothing further known	Returned for Appendicectomy	Died	Discharged: Nothing further known	Returned for Appendicectomy	Discharged: Nothing further known	Returned for Appendicectomy	Died
2nd ..	9	1	1	1	0	2	2	—	—	—
3rd ..	14	0	2	4	1	13	14	—	—	—
4th ..	10	4	3	8	1	17	27	—	—	1
5th ..	4	1	4	6	0	18	23	—	1	1
6th ..	6	2	3	13	1	15	17	—	—	—
7th ..	1	0	0	10	0	9	17	—	—	—
Over 7th	11	2	14	50	2	48	63	4	6	—
Totals	55	10	27	92	5	122	163	4	7	2

Mortality { Appendicectomy and drainage = 15·4 per cent; Drainage only .. .. = 4·03 per cent; No operation .. .. = 0·67 per cent } Mortality in subsequent appendicectomy = Nil.

Complications in Acute Cases admitted with Palpable Mass.

Complicated by	Cases operated on	Cases not operated on
Acute attack	7	11
Residual abscess	12	5
Obstruction	5	2
Pulmonary embolism ..	1	—
Fæcal fistula	3	—
Subphrenic abscess	—	1
Femoral thrombosis	—	1
Totals	28*	20†

* Out of a total of 164 cases operated on = 17·1 per cent.
† Out of a total of 296 cases not operated on = 6·76 per cent.

Conclusion.—In 'appendix mass' cases of all stages, cases operated upon give 7·9 per cent mortality and 17·1 per cent complications. Cases not operated upon give 0·68 per cent mortality and 6·76 per cent complications.

Table IV.—Comparison of an Early with a Recent Group of Cases of Acute Appendicitis operated upon at St. Thomas's Hospital.

Group A (1894–1903).— 433 cases with 182 deaths (42 per cent).

Group B (1920–1929).—1755 cases with 86 deaths (4·9 per cent).

I. Early Acute Cases:—
A.—13 with no death.
B.—1340 with 23 deaths (1·71 per cent).

II. Cases with Diffuse Peritonitis:—
A.—166 with 143 deaths (86·0 per cent).
B.—226 with 48 deaths (21·1 per cent).

III. Cases with Palpable Mass:—
A.—254 with 39 deaths (15·3 per cent).
B.—189 with 15 deaths (7·95 per cent).

the disease. It is for this reason we wish to make it quite clear that we do not consider that every patient in whom an appendix mass can be felt is safe to be left. Careful observation and sound judgement are essential, for out of our 487 cases, 120 required immediate surgical treatment; and of those which appeared likely to subside when first seen, 69 were subsequently explored on account of failure to resolve, or exacerbation of symptoms.

CONCLUSION.

1. All cases of acute appendicitis in which no mass is palpable require immediate surgical treatment.
2. In cases with diffuse peritonitis removal of the appendix is essential.
3. If a palpable mass is present the best results are obtained by conservative treatment, where this is possible.

We are indebted to the surgical staff of St. Thomas's Hospital for permission to publish their cases, and especially to Sir Percy Sargent, who is chiefly responsible for the arrangement of the figures.

REFERENCE.

[1] WALLACE and SARGENT, *St. Thomas's Hosp. Rep.*, 1904.

THE RADIUM TREATMENT OF CARCINOMA OF THE BREAST.

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THE RADIUM PROBLEM.

The radium problem in the treatment of carcinoma of the breast is exactly the same as that which faces purely operative treatment—how to extirpate completely the cells of the primary growth and all secondary growths that may conceivably be accessible. Advance in the surgery of the breast dates from 1867, when Charles Moore,[1] of the Middlesex Hospital, criticized the methods of removal of the breast then practised. He advocated the wide removal of skin and underlying tissues, and of the main lymphatic glands draining the breast. He also enunciated the principle of the centrifugal dispersion of the disease. Since his time the work of Mitchell Banks, Samuel Gross, Halsted, Sampson Handley, and Cheatle (to mention only some of the outstanding names) has fully established the correct principles of surgical treatment, and the operation has been virtually standardized in the removal of: (1) The whole mammary gland with the overlying skin for as great a distance as possible around the primary growth; (2) The underlying fascia and pectoral muscles over a considerably greater area; and (3) The axillary lymph glands and channels from the breast in continuity. Attempts were made by Halsted to extend the operation still further by dividing the clavicle and carrying the dissection up into the supraclavicular region, and Harvey Cushing, working in Halsted's clinic, removed on several occasions the lymphatic glands in the anterior mediastinum. These extensions have not become standardized, chiefly owing to their technical difficulty and the danger to the patient, though also, perhaps, because the results did not justify so difficult and dangerous a procedure. Without them, the operative mortality for cancer of the breast has been extremely low, and, owing to the relative accessibility of mammary cancer, the results, compared with those obtained in other parts of the body, have been good. At the same time there has always been a fairly rigid segregation of the patients into surgical sheep and goats—the two classes known colloquially as 'operable' and 'inoperable'—and in every clinic in this country, as in others, the latter category has been lamentably large. The label 'inoperable' has depended on somewhat gross criteria—obvious local extension of the growth beyond the limits of operation, adhesion of the growth to the chest wall, involvement of lymphatic glands other than those in the axilla, or the presence of metastases in other parts of the body.

The radium problem may therefore be resolved into a series of questions which it is my object in this paper to make some attempt at answering:—

1. Can the primary growth in the breast be eradicated by radium?

2. Can secondary growths in lymphatic glands be eradicated, and what limits must be set to the treatment ?

3. Can radium be used to cure or alleviate the disease in those patients who are already from the surgical point of view 'inoperable' ?

4. Are the final results to be obtained by radium or by radium combined with surgery in 'operable' cases as good as, worse than, or better than those obtained by surgery alone ?

In attempting to answer these questions I shall assume that no miracles can be performed by radium. If the patient already has metastases in other parts of the body, no form of local treatment, whether operative or radiological, will save her life. At the same time it is clear that there is a stage in every case of carcinoma of the breast during which the disease is a local lesion, and therefore any form of local treatment must depend for its success primarily on early diagnosis. This will apply as much to radium as to operation, and since the 'clinical material' at my disposal has been entirely unselected, and for the most part extremely unfavourable, clearly no startling end-results can be expected when they are expressed statistically. The study of individual patients will throw more light than any figures, and case-histories will be an important feature of this contribution to the solution of the radium problem.

THE HISTORY OF RADIUM TREATMENT OF CARCINOMA OF THE BREAST.

The history of the radium treatment of carcinoma of the breast is largely contained within the pages of this article. Until comparatively recent times radiological treatment was reserved for those patients who were clinically 'hopeless'—those who had advanced and inoperable tumours, or were surgical failures, having developed external recurrences after operation. Considerable numbers of such patients had been treated by external application of radium. Thus at the London Radium Institute[2] no fewer than 633 patients had received this form of treatment in the period 1918–27, but only 164 of these had primary inoperable tumours, the remainder having post-operative recurrences. The results obtained were encouraging, 26 out of 128 patients surviving for three years, and 11 out of 98 patients surviving for five years ; but, in spite of this, no advance was made towards treating patients in a more hopeful stage of the disease. In Continental radiological clinics similar classes of cases have been treated, but it has been for the most part assumed that nothing further was possible, and, indeed, that it would be wrong to attempt the treatment of operable tumours with radium. One of the leading Continental authorities, when told recently of work being done in London on newer lines, showed but little interest, and dismissed the subject with the laconic remark, "He will be disappointed."

In treating carcinoma of the breast with radium it is at once obvious that two main methods are available : (1) External irradiation with a comparatively large quantity of radium ; and (2) Interstitial irradiation with a smaller quantity. When in 1922 radium was put into the hands of the Surgical Professorial Unit at St. Bartholomew's Hospital under the direction of Professor G. E. Gask, the amount available was small, and interstitial irradiation was

clearly the method to be chosen, the details of procedure being decided upon in consultation with Dr. N. S. Finzi. The radium was distributed in small units, 1 mgrm. to 1·6 cm. in platinum needles with walls 0·5 mm. thick, and a cautious beginning was made by treating recurrent nodules of growth following radical surgical removal of the breast. It had already been ascertained that interstitial irradiation with a comparatively large quantity of radium, such as a tube containing 50 mgrm., for a short period was apt to prove too intense and to result in damage to normal tissues with necrosis. It was resolved, therefore, from the start of this investigation, to use only the small units, the largest needle containing 3 mgrm. of radium element in an active length of 4·8 cm., and to prolong the time of irradiation by several days.

During the years 1922–4 seven patients with recurrences were treated, and in almost every instance complete disappearance of the growth resulted. One of these patients is alive and well at the present time, nearly eight years after treatment, but the others all died within a comparatively short time from metastases in other parts of the body. Although their lives had not been prolonged, valuable information had been obtained from these preliminary experiments. It was clear that a nodule of recurrent growth, whether surgically removable or not, could be made to disappear almost with certainty, and if this could be done with a recurrent growth, why not also with a primary growth? The conclusion appeared to me to be that primary carcinoma of the breast might be successfully treated in the same way, and with Professor Gask's concurrence it was decided to attempt this, the experiment being limited to patients whose tumours were regarded as inoperable according to the ordinary standards.

The first patient to be treated in this way was a woman aged 47 with a small carcinoma of the left breast which had been present for three years and had become adherent to the chest wall, so that it was inoperable. The treatment was given on Aug. 1, 1924, and the full case-history is as follows:—

Case 1. Age 47. Referred to the Surgical Unit as inoperable by Mr. H. W. Wilson. A small lump had been noticed at the upper and inner quadrant of the left breast for three years. On examination the patient was found to have a hard contracting tumour, 3 × 4 cm., which was infiltrating the skin, ulcerated in the centre, and adherent to the pectoral muscle. Radium treatment was given on Aug. 19, 1924, 52·8 mgrm. of radium element being inserted deep to the growth for 24 hours. A month later the ulcer, present for a year, had healed. The whole mass was smaller and more mobile, and the patient had gained 5 lb. in weight in three weeks. A second treatment was given on Dec. 4, 11·5 mgrm. being inserted for 120 hours. Further improvement resulted, and the breast began to fall towards its normal position. By July 2, 1925, the growth had disappeared except for some small nodules in the skin, and this remaining portion of the growth was excised. The presence of carcinoma in the nodules was confirmed by section. On Jan. 18, 1927, the patient had no local recurrence, but there was a palpable gland in the left axilla, and the lymph areas were then treated in the ordinary way. The axillary gland had disappeared by April 4, 1927. The patient remained well until Nov. 5, 1929, when a nodule of growth was found in the skin of the areola—that is, outside the area originally treated. A fourth treatment was given for this on Jan. 10, 1930. The patient is alive without signs of active disease at the present time (7 years after the initial treatment). (*Figs.* 312, 313.)

This patient suffered by reason of having come before the technique had been developed, so that she had to be treated in four stages. Ultimately,

however, the full treatment was given, and the patient, who started with an inoperable growth seven years ago, is quite well at the present time.

In the first two patients treated there happened to be no palpable lymphatic glands, and treatment was given only to the primary growth. As soon as a patient with palpable lymph glands was to be treated, the question arose whether the lymphatic areas were to be treated at the same time as the primary growth. It was decided to insert needles in the axilla and below the clavicle, and to do this as a routine whether glands were palpable or not. The effect on lymphatic glands already enlarged was found to be remarkably good, and as a prophylactic measure the treatment also seemed to be successful.

FIG. 312.—*Case* 1. Before excision of scar.

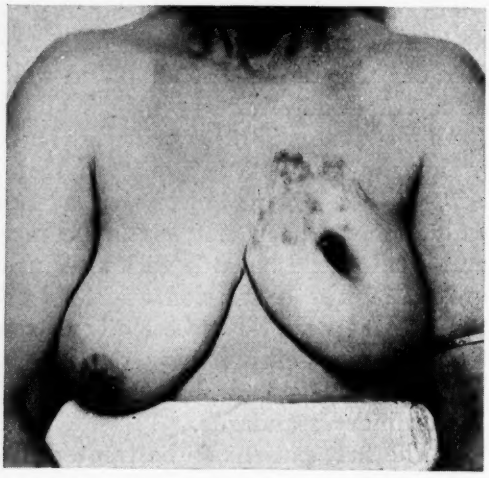

FIG. 313.—*Case* 1. Seven years after treatment.

In June, 1925, the routine treatment was extended to the supraclavicular glands, and soon afterwards needles were usually inserted into the upper three or four intercostal spaces with the object of irradiating the internal mammary lymph glands.

The results obtained in inoperable tumours during 1925 were so favourable that in 1926 I urged that the treatment should be extended to operable tumours, and with Professor Gask's approval the first operable growth was treated with radium on March 23, 1926.

The routine treatment was now fully established, and with minor variations has been since carried out by the Surgical Unit at St. Bartholomew's, by myself at St. Bartholomew's, at the Mount Vernon Hospital, Northwood, and on private patients.

More recently primary tumours, chiefly inoperable, have been treated with radium by Stanford Cade and E. Rock Carling at the Westminster Hospital. Small numbers have also been treated by others elsewhere, but very little on the subject has yet been published in confirmation or the reverse of my results. The technique used at the Westminster Hospital was essentially different from mine, being done chiefly with 1-mgrm. needles inserted at right angles to the skin, and the interstitial irradiation has been

supplemented with superficial irradiation through Columbia paste as described by Stanford Cade.[3]

From the beginning of this investigation the 'Follow-up Department' at St. Bartholomew's Hospital under Miss Ball has been an exceedingly important factor in carrying on the work. Miss Ball's skill in keeping in touch with patients after their initial treatment has contributed largely to the value of the results that have been obtained, and her work must take its place in the history of the opening stages of the radium treatment of carcinoma of the breast.

TECHNIQUE.

At the present time the technique involves the treatment of two main areas: (1) The breast and primary growth; (2) The accessible lymphatic areas. This separation is made owing to the fact that whereas the lymphatic areas require an almost constant amount of radium, the amount required for the primary growth is very variable. Two or three times as much radium may be needed for a large breast in a stout patient as for a small contracting growth in the breast of a thin patient. It is therefore impossible to lay down rules for dosage. Any statement that so many milligramme-hours is the correct standard would be entirely misleading with so variable a factor in the calculation. The only rough guide that can be given is the empirical observation that the best results seem to be obtained in the breast by using needles of 3 mgrm. in an active length of 4·8 cm. with a filtration of 0·5 or 0·6 mm. platinum, placed about 1·5 cm. apart (*Fig.* 314). That is to say, for an area of breast 4·8 × 4·5 cm. (21·6 sq. cm.), 9 mgrm. of radium will be required, or approximately 1 mgrm. for each 2·5 sq. cm. of breast. This calculation takes no account of the thickness of the tissue to be treated, and sometimes in a stout patient additional needles have to be inserted in another plane, nearer the surface. Experience is the best guide in this matter, for an overdose may result in very unpleasant consequences for the patient. It has been my practice to insert the needles as far as possible in a plane deep to the growth, usually in fact under the deep surface of the mammary gland itself—that is, in the plane of the pectoral fascia. My reasons for this have been several:—

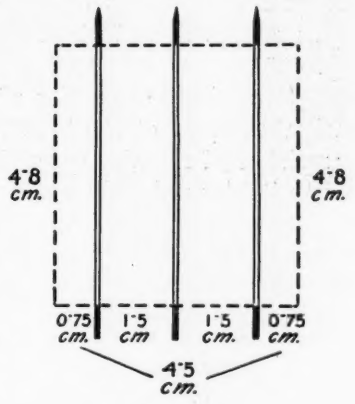

FIG. 314.

1. Pushing needles into the growth itself, or even its immediate surroundings, has appeared to me to involve the risk of transplanting carcinoma cells into tissue previously uninfected. The ends of the needles are very feebly radio-active, so that any cells carried on the point will not be effectively irradiated.

2. Needles introduced into the sometimes poorly nourished tumour tissue may exert too intense a local effect, with risk of subsequent necrosis. Radium treatment can usually be made effective without necrosis and its attendant discomforts to the patient.

3. The main lymph channels draining the breast run in this plane deep to the breast.

4. The skin, being very susceptible to burning by radium, is liable to be injured unless screened by the breast tissue from the rays.

5. The breast tissue is often extremely tough, and needles may easily be damaged if any force has to be used while inserting them.

6. Experience has shown that when the mammary gland is not too thick an entirely satisfactory result can be obtained by this deep irradiation, sometimes without skin-burning or other disadvantage.

When the tumour or the breast is large I have sometimes departed from this principle by inserting additional needles more superficially, though these are usually in the neighbourhood of the growth rather than in it.

The needles are disposed as evenly as possible, sometimes in a cartwheel fashion, sometimes covering a quadrangular area. In the past the error has occasionally been made of covering an insufficient area of breast surrounding the primary tumour. Sir Lenthal Cheatle[4] has recently stressed the fact that there are often many 'secondary deposits' in the breast itself outside the primary tumour; and therefore ideally the whole mammary gland should be irradiated in every case, and thus recurrences in the breast outside the area treated should be avoided. It is particularly important not to leave a gap of untreated breast between the tumour and the anterior fold of the axilla. This point will be further discussed in the section dealing with causes of failure (p. 451).

Sometimes the series of needles is continued under an area of skin in the neighbourhood of the breast, particularly towards the mid-line, if there is any suspicion of nodules spreading there. A much larger area than that actually occupied by palpable nodules must be irradiated. (*Fig.* 315.)

The accessible lymphatic areas are all treated in accordance with the known channels of lymphatic drainage of the breast. As demonstrated by Sappey in 1885, the largest channels run round the outer border of the pectoralis major muscle—that is, in the anterior axillary fold—towards the axilla. It is a matter of common observation that in the great majority of patients the axillary glands are the group to be first infected with secondary growths, and it is reasonable to infer that carcinoma cells (whether they spread by multiplication in continuity, by active movement, or by embolism) take the line of least resistance—that is, towards the axilla in the first place. The treatment of the subpectoral lymphatics and of the axilla is therefore of the first importance and must never be omitted. This is best effected by the long needles (3 mgrm. in 4·8 cm. active length) inserted beneath the pectoral muscle, and, in continuity, into the axilla. Those in the axilla are placed on each wall in turn, four or five being placed so as to converge towards the apex. These can be placed with great accuracy through punctures in the skin, though care must be exercised not to pierce the pleural cavity by the needle on the inner and posterior wall, and not to injure vessels or nerves by that on the outer wall. The latter structures are safeguarded by keeping the upper arm abducted at a right angle from the body and inserting the needle in a direction parallel to the position of the neurovascular bundle and not too close to it.

The third lymphatic area for needles is the infraclavicular. It is not uncommon, when operating for carcinoma of the breast, to find enlarged glands running up from the axillary group over the costocoracoid membrane to a position almost behind the clavicle. Needles are therefore inserted below and more or less parallel to the middle third of the clavicle. Except in very stout patients, there is not room for the long needles, and it is better to use two or three needles each containing 2 mgrm. in an active length of 3·2 cm. These are inserted through skin punctures and are directed towards the axilla, but are plunged at first almost directly backwards so as to pierce the pectoral muscles. Their points should lie close to those of the needles in the axilla so that they may contribute to the irradiation of the apex of the axilla. Their radiations will also pass backwards to the costocoracoid membrane and upwards behind the clavicle.

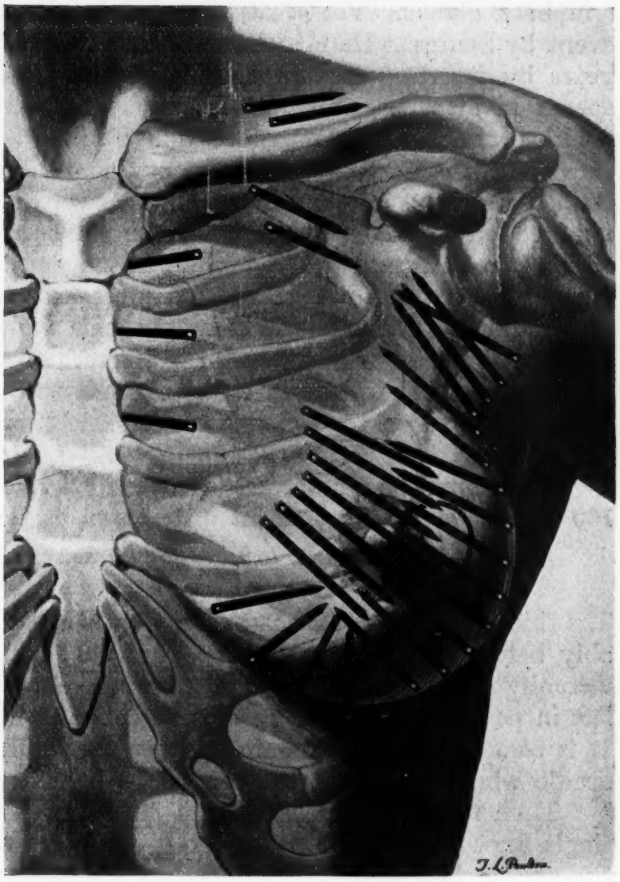

FIG. 315.—Diagram showing usual distribution of needles.

The fourth lymphatic area is the supraclavicular. The glands in this area are commonly the next ones to become enlarged after the axillary glands. Occasionally they are affected before anything is palpable in the axilla, suggesting that there are some lymphatic channels passing directly upwards from the breast to the supraclavicular region without visiting glands in the axilla. Sometimes enlargement of these glands is undoubtedly due to an extension upwards of the disease from the mediastinum, in which case radium treatment is unlikely to be of any avail; but it is seldom possible to be certain of this, and the supraclavicular group is certainly to be included in the routine treatment, thus extending the treatment beyond what is usually attempted by surgery, in spite of Halsted's earlier attempt to remove them. The needles, usually two or three of the shorter kind, are inserted through skin punctures from within outwards, parallel to the middle third of the clavicle. They should be plunged at first backwards through the deep cervical fascia so as to pass behind the posterior part of the sternomastoid muscle and the external

jugular vein. They then enter the loose areolar tissue at the root of the neck, and no force should be necessary to get them into position. If they are passed too deeply backwards, they will injure the brachial plexus, or if too much downwards may pierce the subclavian vein. If no force is used, neither of these accidents will occur.

The fifth lymphatic area includes the upper four intercostal spaces. During the 'following-up' of several hundred patients treated for carcinoma of the breast by surgery or radium in the course of the last eleven years I have never seen an intercostal recurrence traceable to one of the internal mammary lymphatic glands. Yet great stress has been laid upon the possibility of this event by Sampson Handley[5], and I have followed his lead during the last four years by inserting radium needles into at least the upper three intercostal spaces in most patients. It is very dangerous to use long needles in this position, and the skin punctures must be made at a sufficient distance from the edge of the sternum. A needle of 2 mgrm. in 3·2 cm. active length is then pushed in very obliquely between the ribs, and the point must be felt to impinge on the lateral border of the sternum. The needle is then partly withdrawn and pushed in again slightly deeper so as to pass just behind the edge of the sternum. It should not project more than 1 cm. into the anterior mediastinum. If the needle is kept in this way very close to the sternum, it will not be in danger of injuring the pleura, pericardium, or internal mammary artery, though it will be in close proximity to the internal mammary gland. Any misjudging of the position of these needles may result in the loss of the patient's life.

A distribution of needles as described above will require up to about 100 mgrm. of radium element distributed as follows :—

10	needles	2	mgrm. Ra	each,	3·2	cm.	active length
25	,,	3	,,	,,	4·8	,,	,,

The thickness of the platinum cases should be at least 0·5 mm., and it is probably better to have 0·6 mm. or even 0·8 mm. With the greater thickness virtually the whole of the β radiation is removed, so that the needles may be left in position for longer periods with less fear of damage to normal tissues. It is also a considerable gain to have the additional strength of the thicker needle when the tissues are tough.

Each needle is threaded on a strand of thick salmon gut, which has a single knot about 2 cm. from the eye of the needle. If the knot is close to the eye, the extraction of the needle is rendered more difficult. Salmon gut is used in preference to any form of thread, because it is non-absorbent, so that the punctures in the skin remain more completely aseptic than if silk is used, whether carbolized or plain. The salmon gut does not crack if it is kept moist for twenty-four hours before use. The strands of salmon gut are knotted together in groups of four or five, thus guarding against loss of any one needle should it be accidentally pulled out of the tissues. The knotted strands are wrapped in gauze to prevent irritation of the skin, and the whole area is covered with adhesive rubber strapping as a further safeguard against displacement or loss of needles.

The needles are usually left in position for a period of 7 days (168 hours). It has been found empirically that this period of irradiation gives satisfactory

results with the dosage employed, and from the point of view of hospital organization a 7-day period is the most convenient arrangement. It has also been found that this exposure very seldom produces necrosis of the tumour. The skin not infrequently shows a superficial burn, which is satisfactory evidence that the irradiation has penetrated the tissues. Occasionally with a stout patient it may be advantageous to increase the period to 8, 9, or even 10 days, but it should scarcely ever be reduced to a shorter period than 7 days.

While the needles are in position the patient should be kept in bed and the arm on the affected side should be at rest, though it need not necessarily be kept in a sling. Most patients suffer but little pain except on movement; some of them complain of nausea while being irradiated, or may even vomit occasionally.

The needles are usually inserted under gas and oxygen anæsthesia. The operation is brief, and the patient suffers the minimum of disturbance with this anæsthetic. Removal may be effected in the same way, though a general anæsthetic is not an absolute necessity. Usually most of the needles can be extracted without any anæsthetic at all, and for those that are caught up in the subcutaneous tissue a few minims of novocain solution injected round the skin puncture are all that is needed.

After removal of the needles the punctures heal very rapidly and leave but little trace, though usually there is just enough scar to serve as a useful indication of the precise area that has been irradiated. Should the skin reaction be excessive, the peeled area will have to be dressed for several weeks, liquid paraffin or some neutral application being the best.

AFTER-CARE.

As I have already mentioned above, the routine examination of the patients at intervals after treatment is an absolutely necessary part of the work—not only so that the surgeon may obtain information as to the efficiency of the treatment, but also because, in treating unselected cases, a single radium treatment must often be followed by further treatment, radiological or surgical.

During the present investigation I have usually seen the patients at monthly intervals after treatment for three to five months, then at three-monthly intervals for a year or more, and the interval has afterwards been lengthened to six months or longer, as time passed and confidence increased. Patients are also instructed to report themselves without being summoned if anything suspicious has been noticed.

When the needles are removed there is usually little change to be seen in the tumour or glands. Within a fortnight, however, there is often an appreciable alteration in size. As the weeks pass this becomes progressively more obvious, and sometimes, if the tumour was not large, or was particularly radio-sensitive, it may have disappeared completely at the end of five or six weeks after irradiation. A larger or less sensitive tumour will go on shrinking for a much longer period, and it may be three, four, or even five months before the full effect has been obtained. For this reason I have always been slow to apply further treatment, surgical or radiological, and in addition there is

nearly always a long latent period after treatment during which no renewed activity will appear even if the carcinoma is not completely destroyed. A rapid recurrence in the breast was seen in one patient who had had an inadequate treatment in the first place, but this is very exceptional (*Case* 50).

One factor in the problem is liable to produce an unfortunate uncertainty in the surgeon's mind, and that is the unknown quantity of fibrous connective tissue in the tumour and its surroundings. It was formerly supposed that one of the effects of exposure to radium was the formation of fibrous tissue, but possibly this was due to the caustic effect of the β rays, the amount of radium having been greater and the filtration less than in recent times. Certainly 'fibrosis' has not been an obvious feature of my treatment of carcinoma of the breast. On many occasions, indeed, the breast has become so soft and approximated so nearly to the normal that it has seemed that fibrous tissue has disappeared rather than formed.

Case 68.—Age 52. Lump noticed in right breast for more than a year. On examination there was a hard indefinite mass under the areola, 6 cm. in diameter. Nipple retracted. Skin not attached. Several hard enlarged glands in right axilla. Operable. Radium treatment on June 12, 1929. By Dec. 4 there was no discoverable sign of disease. The breast was quite soft and apparently normal. The patient has remained well since (2 years, 3 months).

Case 73.—Age 44. Lump noticed in right breast for several months. On examination there was an indefinite flat mass, 5 cm. in diameter, in the upper inner quadrant, adherent to the skin. No palpable glands. Operable. Radium treatment on June 26, 1929. By Aug. 28 slight thickening only was detected. At the present time the breast is quite soft and apparently normal (2 years, 2 months).

Case 83.—Age 58. Lump noticed in left breast for two years. On examination there was a very hard lump in the axillary tail of the breast, 2·5 × 2 cm. Hard enlarged gland, 2 cm. in diameter, above this. Radium treatment on Sept. 11, 1929. By Nov. 21 both lumps had completely disappeared, and the breast has been apparently quite normal since that time (2 years).

On the other hand, many tumours undoubtedly contain a large amount of fibrous tissue which remains after the disappearance of the malignant cells, so that there is a residual tumour even though the treatment has been completely successful. Sometimes, also, the fatty tissue of the breast becomes denser and firmer after treatment, and this may also result in an apparent residual tumour. Very frequently the tumour disappears completely but the portion of the breast affected remains slightly thicker and firmer than the rest. This need not give rise to anxiety; but whenever there is an undoubted residual tumour I have always thought it wiser to give a second treatment or to remove a portion or the whole of the breast; occasionally I have done the removal after a second treatment. In some of the specimens thus obtained no residual carcinoma has been found; a fuller account of this will be found in a later section.

Another phenomenon which sometimes follows treatment is œdema of the skin overlying the breast. In several instances the breast underneath has been quite soft and has remained so; the œdema therefore may be due to lymphatic obliteration and not to recurrent growth.

Case 65.—Age 33. Lump noticed in left breast for five weeks. On examination there was a swelling in the upper outer quadrant, 2·5 cm. in diameter, not attached

to skin or deep fascia. Slight retraction of nipple. Large gland palpable in left axilla. Radium treatment on May 31, 1929. By Oct. 8 no tumour could be felt and no glands were palpable. On July 21, 1930, some œdema of the skin on the outer side of the breast was noted. A second radium treatment was given on Sept. 23. The œdema of the skin somewhat increased, but no tumour could be detected. The patient, however, developed signs of pulmonary metastases, and died on June 30, 1931.

DIAGNOSIS.

It was clear from the outset of this investigation that it was necessary to set beyond doubt the nature of the disease that was being treated. I determined, therefore, to remove a specimen for microscopic examination from every patient, and this was done systematically in the first fifty patients treated. The specimen was taken at the time of *removal* of the needles—that is to say, after the growth had been irradiated for seven days or more. There are obvious theoretical objections to the removal of this specimen, such as the possibility of disseminating the growth by blood-vessels or lymphatics, or the encouragement of local growth. It was hoped to avoid these disasters by removing the specimen only after irradiation, with the idea that the growth of the malignant cells would have been inhibited, although their histological characters appeared to be unchanged. In this hope I was deceived, although the procedure afforded interesting information as to the biological behaviour of irradiated malignant cells. For in two patients an implantation growth appeared in the scar of the skin incision through which the specimen had been removed, although the primary tumour disappeared as the result of the treatment. In both of these patients further treatment was necessary, and in one of them the interference with the growth proved to be disastrous.

Case 26.—Age 39. Lump noticed in left breast for nine months. On examination there was a hard irregular lump in the upper part of the breast, 5 × 4 cm. in size, 2·5 cm. thick, attached to the skin. No glands palpable. Radium treatment on Dec. 16, 1927. Section removed on Dec. 23 showed spheroidal-celled carcinoma. On March 12, 1928, the original tumour had disappeared, but there was a small hard mass immediately under the scar of the biopsy incision. A second treatment was given to this on April 12, and by July 3 the swelling had disappeared. The patient remained well until Nov. 28, 1929, when a third treatment was given for secondary gland in the axilla. The patient subsequently developed signs of pulmonary metastases, though she is still alive at the present time.

Case 32.—This case is described on p. 448 under a different heading.

It appears, therefore, that an irradiated cell, though destined to disappear if left in its original site, may survive and multiply if transplanted to new surroundings. This observation may throw some light on the question of the effect of irradiation on malignant growths, whether it destroys the malignant cells, stimulates the other tissues to absorb them, or interferes with their blood-supply.

The observation was, indeed, too disturbingly interesting from the point of view of the patient's welfare, and I decided that the experiment was more suitable for performance on laboratory animals than on human beings. I considered, also, that histological proof of the nature of the disease in fifty consecutive cases was sufficient evidence in establishing the clinical results of radium treatment, especially as it had been obtained in some crucial cases,

notably the one described below under the heading of CLINICAL EVIDENCE. The histological proof has been obtained in a few later cases, when a local excision has been done before or after irradiation; but the diagnosis in the last hundred patients has depended for the most part on clinical evidence alone. The clinical diagnosis is, indeed, all too clear in most instances, and it is to be regretted that surgical teaching is still usually directed to emphasizing the late evidences of carcinoma of the breast rather than the early. When the diagnosis is clear the disease is usually past the earliest stage, and a number of patients in the present series who have been examined by their doctors during the early stage have been told to wait and so have only come for treatment when the diagnosis was obvious.

Carcinoma of the breast is so common a disease that suspicion should constantly be on the alert to detect it before puckering of the skin and other signs can be detected. Cysts of the breast, often difficult to distinguish by the fingers only, can always be excluded by the use of the exploratory syringe. The transillumination method of diagnosis, described by Max Cutler,[6] is of limited application, as the light cannot always be made to lie behind the growth unless the breast is somewhat pendulous, and I have been disappointed in its use. A fibro-adenoma usually presents the feature of mobility in the mammary gland, but I have on several occasions seen an equally mobile solid tumour which proved to be a nodule of carcinoma, and it is certain that every such tumour in a patient over the age of 25 should be regarded with suspicion. Another prevalent source of confusion is the condition designated 'mastitis', which may be closely simulated by a carcinoma growing somewhat diffusely from the start. Here the consistency, usually rather hard, should give the clue before there are any of the more obvious signs to be detected. I believe that an experienced clinician will make very few mistakes, and that in any case it is better to err on the side of diagnosing carcinoma too often than to miss it in the early stage. I think it is unlikely that many mistakes have been made in the present series. An exact record of the clinical findings has always been made in writing and is available for reference. Those patients in whom I felt there was genuine doubt as to the diagnosis have not been included in my records, so that if I have made an error it cannot amount to more than 1 or 2 per cent.

EFFECT OF IRRADIATION ON TUMOURS.

It is necessary to describe in some detail the effect of interstitial irradiation given by this technique, and to take separately the different forms of growth. As it has not been my practice in recent years to obtain a section of the growth as a routine, it is not possible to 'grade' the tumours on any scientific basis such as Broders' classification. They will therefore be roughly classified on a clinical basis as 'early', 'intermediate', and 'advanced'.

1. **Early Growths.**—An early growth is a thing somewhat difficult to define, the patient's statement that it has only just been discovered so often being no proof that it is in an early stage. In general an early growth may be regarded as one which is small, which shows little sign of contraction or adhesion to neighbouring structures, and which is not associated with enlarged

lymph glands. It is rare to find this type of growth among hospital patients, but much more frequent in private practice—that is, among the more educated classes. The effect of irradiation, as would be expected, is most rapidly apparent with the smallest tumours, even though they were of stony-hard consistency. Sometimes the tumour has completely disappeared within five weeks of removing the radium, and in such cases no recurrence has so far taken place. I have been able to place only 14 patients in the 'early' class, and in 7 the results are as detailed below. In the remaining 7 patients the carcinoma was excised locally before radium treatment was given, and these cases are described on p. 456.

Case 59.—Age 63. Lump noticed in right breast for two weeks. On examination there was a firm flat swelling, 2·5 cm. in diameter, in the inner upper quadrant. Skin slightly attached. No enlarged glands felt. Radium treatment given on April 9, 1929. On May 15 the tumour had completely disappeared, and the patient has remained quite well since (2 years, 5 months).

Case 66.—Age 57. Lump noticed in left breast for fifteen days. On examination in the inner upper quadrant was a firm rounded lump, 1·5 cm. in diameter, not adherent to the skin. Proved by aspiration not to be cystic. No glands palpable. Radium treatment given on June 8, 1929. By Sept. 20 the lump had completely gone, and the patient has remained well since (2 years, 3 months).

Case 98.—Age 73. Lump noticed in right breast for ten days. On examination a lump of 4 cm. in diameter was felt beneath nipple, which was retracted. No glands detected. Radium treatment given on April 9, 1930. One year later the patient was without signs of disease (1 year, 5 months).

Case 99.—Age 48. In the lower outer quadrant of the right breast was a hard lump, 4 × 2 cm., slightly attached to the skin. No glands palpable. Radium treatment given on March 21, 1930. The lump had disappeared two months later, and the patient has remained well since (1 year, 7 months).

Case 105.—Age 60. Lump noticed in right breast for one week. On examination there was a very hard lump, 2 cm. in diameter, in the upper outer quadrant, slightly attached to the skin. Small gland palpable in axilla. Radium treatment given on March 1, 1930. Patient next seen on Oct. 19 and found to be without sign of disease, and she has remained quite well since (1 year, 6 months).

Case 127.—Age 52. Lump noticed in right breast for three months. On examination there was a hard lump, 4 cm. in diameter, just above the nipple. Not attached to the skin. Soft gland palpable in axilla. Radium treatment given on March 17, 1930. On Aug. 27 the lump had disappeared and no glands could be felt. The patient has remained well since (1 year, 1 month).

2. **Intermediate Growths.**—These are still more difficult to define, though they are found in a considerable proportion of the patients treated. In general, the growths are of fair size, though not associated with ulceration, marked contraction, or large secondary glands. In such cases the tumour is likely to be perceptibly smaller after four or five weeks, but the full effect may not be obtained until three months, or more, have elapsed. Growths of this type often have a considerable amount of fibrous stroma which accounts for a good proportion of their bulk. It is remarkable how, in many instances, this fibrous stroma disappears (presumably after the carcinoma cells), leaving the breast in the end quite soft and normal to palpation. As already mentioned, radium treatment does not often result in *fibrosis*, when the dosage has been

correctly gauged. Fibrous tissue actually tends to disappear, so that sometimes a breast which was previously elevated drops to its normal level, and nipples which were retracted become again prominent (*see Cases* 15, 59, 68, 73).

Case 40.—Age 57. Lump noticed in left breast for two months. On examination there was a large swelling in the upper part of the breast, adherent to the chest wall and to the skin, 6 × 3·5 cm. in diameter. No enlarged glands detected. Radium treatment on June 8, 1928. Section showed a highly anaplastic carcinoma. By Sept. 5 the tumour had completely disappeared. A small ulcer developed subsequently, but healing took place, and the patient has remained quite well to the present time (3 years, 3 months).

Case 19.—Age 70. Lump noticed beneath left nipple for five years. On examination the nipple was retracted and the skin on either side depressed and reddened. Under the nipple was a lump 2·5 cm. in diameter. There was a secondary growth in the axilla, adherent to the skin, 2 cm. in diameter. Radium treatment on Aug. 2, 1927. Both primary and secondary growths had disappeared by Oct. 10, and the patient has remained well since (4 years, 1 month).

Case 113.—Age 40. Lump noticed in left breast for four months. On examination there was a swelling, 5 × 4 cm., above the nipple, which was retracted and inverted. No palpable glands. Radium treatment on March 20, 1930. By July 2 the lump had quite gone, and the patient has remained well since (1 year, 5 months).

Case 130.—Age 61. Lump noticed in right breast for fifteen months, and another in right axilla four months. On examination there was a hard lump in upper outer quadrant, 3 cm. in diameter, not attached to skin or fascia. Hard gland palpable in right axilla. Radium treatment on Aug. 28, 1930. On Dec. 12 the primary tumour had completely gone. The gland was still palpable. On Feb. 3, 1931, there was no discoverable sign of disease, and the patient is apparently quite well at the present time (1 year).

Case 15.—Age 40. Lump noticed in left breast for one year. On examination the breast was elevated and the nipple retracted, with a lump, 2·5 × 3 cm., beneath areola. Tumour attached to the skin and the nipple. Gland palpable in left axilla.

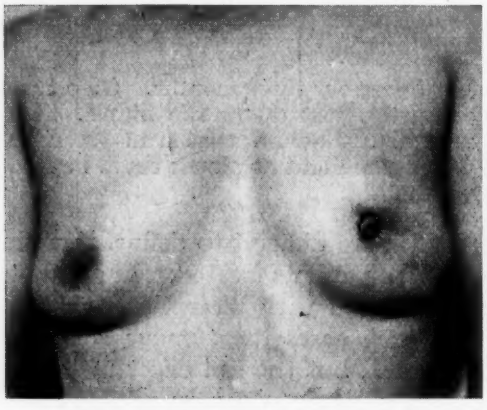

FIG. 316.—*Case* 15. Before treatment.

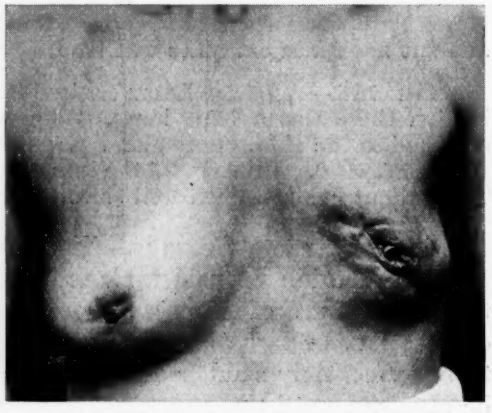

FIG. 317.—*Case* 15. Three years after treatment.

Radium treatment on Feb. 17, 1927. Section showed spheroidal-celled carcinoma with much fibrous tissue. Some puckering of the skin followed with complete disappearance of the tumour and the gland by June 13. The patient has remained well since (4 years, 6 months). (*Figs.* 316–318.)

Case 62.—Age 58. Lump noticed in right breast for six months. On examination hard swelling, 2·5 × 2 cm., in upper inner quadrant, attached to the skin. Slight retraction of nipple. Small gland palpable in right axilla. Radium treatment on May 3, 1929. On July 16 most of the tumour had disappeared, leaving a small knob, 1·5 cm., attached to the skin. Gland no longer palpable. All trace of the disease had gone by July 8, 1930 and the patient has remained quite well since (2 years, 4 months).

In all these examples a satisfactory result has been obtained with growths of considerable extent, and it is with the gradual multiplication of cases such as these that real confidence in the treatment begins to grow. These patients have been relieved of all signs of disease and are virtually normal women, without mutilation or serious disfigurement.

FIG. 318.—*Case* 15. Position of radium needles.

3. **Advanced Growths.**—These may be further classified as massive, fungating, ulcerated, or contracting. As is well known, some of the advanced but contracting growths are favourable as regards end-results, because the contraction may denote active and successful resistance by the patient's tissues. On the other hand, they are often not amenable to operation owing to their being adherent to the chest wall, so that they would be universally recognized as suitable for treatment by irradiation. Such growths often

FIG. 319.—*Case* 3. Before treatment.

FIG. 320.—*Case* 3. Two months after treatment.

respond extremely well to radium, and, although too much tissue may have been destroyed by the growth for the breast to be restored to normal, sometimes no trace remains except a permanent depression in the skin. The effect will usually be obtained within five months.

Case 3.—Age 43. Lump in right breast noticed for two years. On examination the right nipple was retracted and elevated. There was a very hard growth in the inner upper quadrant, 5 × 2·5 cm. in size. Skin infiltrated, forming a bluish depression, with raised red edges. Growth fixed to pectoral fascia. Enlarged

FIG. 321.—*Case* 3. Position of radium needles.

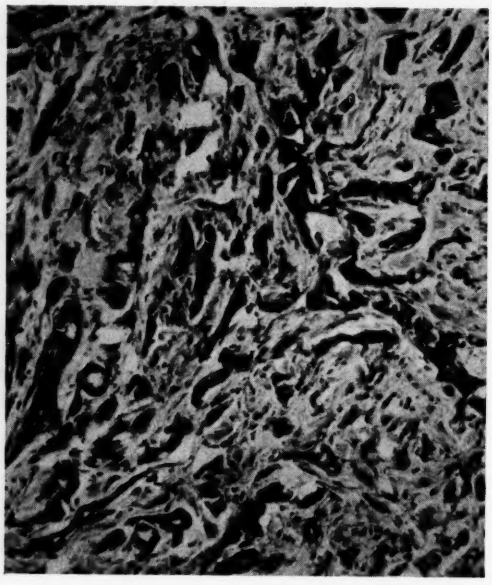

FIG. 322.—*Case* 3. Section showing fibrous tissue infiltrated with spheroidal cells.

glands felt in right axilla. Radium treatment on May 5, 1925, 27·5 mgrm. being applied to the breast for 8 days. The lymphatic areas were treated in stages. Section removed on May 13 showed much fibrous tissue infiltrated with spheroidal-celled carcinoma cells. On Aug. 10, three months after treatment, no tumour could be detected. The glands disappeared, and the patient is perfectly well at the present time (6 years, 4 months). (*Figs.* 319–322.)

Case 8.—Age 57. The only male patient in the series. Irritation and pain in the left breast for one year. On examination there was a lump beneath the left nipple, 2·5 cm. in diameter, attached to the skin and pectoral fascia. Nipple retracted, areola drawn in, and much reduced in size (*Fig.* 323). Skin infiltrated on the mesial side. Palpable gland in axilla. Radium treatment in two stages, on March 23 and April 6, 1926. Section removed on March 23 showed spheroidal-celled carcinoma. The tumour had completely disappeared by Aug. 9, and the patient remained free from recurrence until he died of intercurrent disease on Oct. 16, 1927 (1 year, 7 months).

Case 11.—Age 49. Lump noticed in left breast for eighteen months. On examination, in the lower half of the left breast was a large hard indefinite mass, firmly fixed to the chest wall. Skin over it attached and puckered. No glands detected. Radium treatment on Aug. 6, the needles being applied in three layers. Section removed on Aug. 12 showed spheroidal-celled carcinoma, with much fibrous tissue. On Jan. 3, 1927, no tumour could be felt, and the patient has remained free from local recurrence since that date (5 years, 1 month).

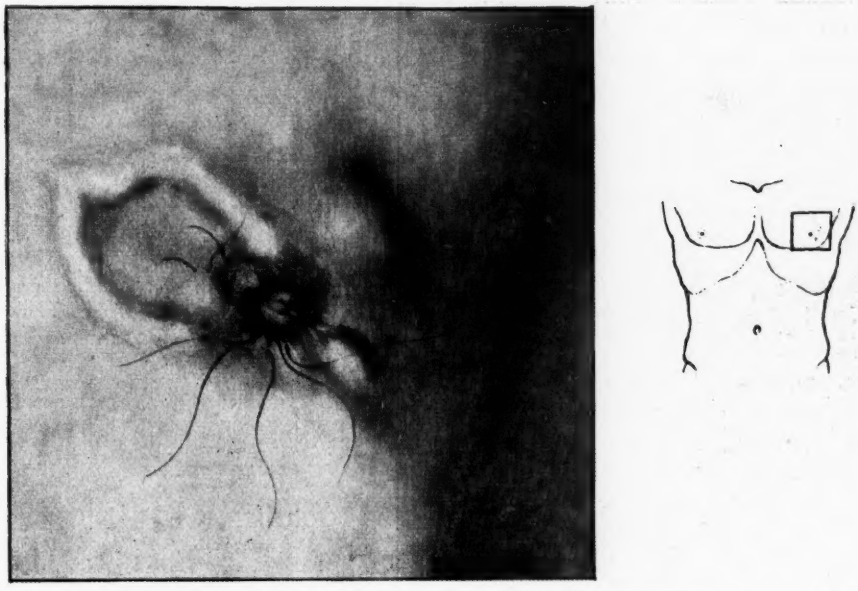

FIG. 323.—*Case* 8. Carcinoma of male breast before treatment.

Case 24.—Age 48. Pucker noticed in left breast for two years. On examination a hard swelling, 5 × 2·5 cm., in inner half of breast, fixed to chest wall. Breast elevated, nipple retracted. Hard gland palpable in left axilla. Radium treatment on Nov. 4, 1927. Section showed spheroidal-celled carcinoma. By Feb. 13, 1928, no tumour could be detected, and the gland had disappeared. No recurrence of the disease since (3 years, 10 months). (*Figs.* 324–327.)

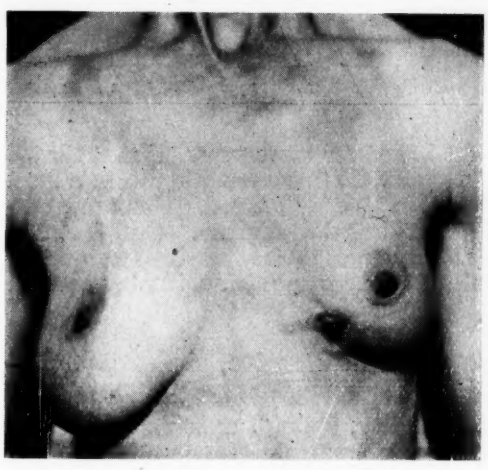

FIG. 324.—*Case* 24. Before treatment.

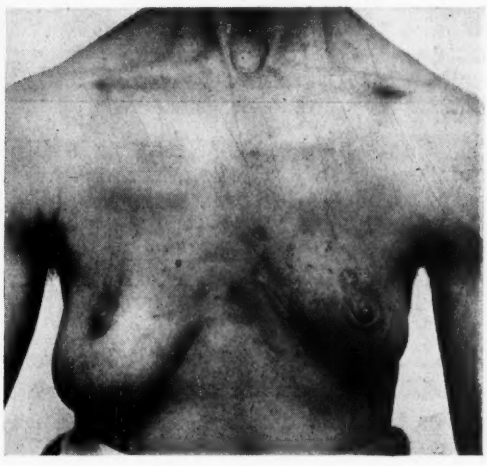

FIG. 325.—*Case* 24. Four months after treatment.

Case 27.—Similar to the above, but a second radium treatment was required for a recurrence near the axilla (*see* p. 451).

Case 36.—Age 68. Lump noticed in left breast for one year. On examination the breast was elevated and the nipple retracted. Above the nipple was a purplish

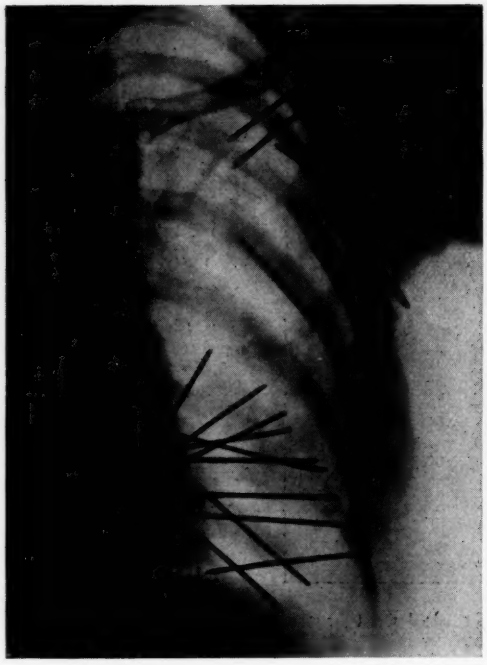

FIG. 326.—*Case* 24. Position of radium needles.

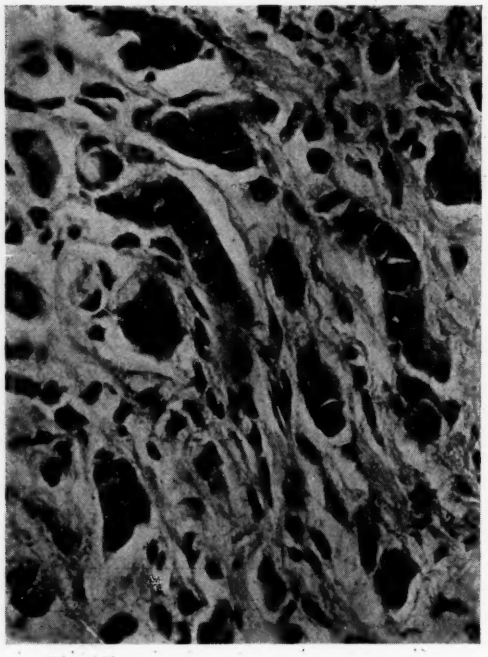

FIG. 327.—*Case* 24. Section showing spheroidal-celled carcinoma.

lump, 4 cm. in diameter, ulcerated in the centre, edges irregular. Growth about 2·5 cm. thick, fixed to chest wall. No enlarged glands palpable. Radium treatment on May 11, 1928. Section showed spheroidal-celled carcinoma. By Nov. 14 only a small crater remained at the site of the growth with some hard nodules round the margin. On April 11, 1930, the crater was still not quite healed, and a second radium treatment was given. Healing took place soon after. Some hardness remains at the original site, but no evidence of active disease (3 years, 4 months.)

Case 43.—Age 63. Lump noticed in right breast for three years, ulcerated nine months. On examination, in the upper outer quadrant was a flat ulcer with a hard raised rim, 5 cm. in diameter. Not adherent. No glands detected. Radium treatment on July 6, 1928. Section showed spheroidal-celled carcinoma. By March 13, 1929, the ulcer was healed and no evidence of disease could be found. The patient died on Dec. 11, 1930, from pulmonary metastases without any sign of local recurrence (2 years, 5 months).

The other categories of advanced growths, massive, fungating, and ulcerated, have been all too common among the patients treated. In fact no fewer than 23 of them have been unscientifically, though expressively, catalogued as 'hopeless' when first seen—that is to say, it was almost inconceivable that they could be benefited by treatment of any kind. Indeed, throughout this investigation no patient has ever been refused treatment except on the ground of obvious visceral or skeletal metastases, so that statistics cannot be regarded as having been vitiated by 'selection'. Nevertheless, the treatment even of apparently hopeless cases has occasionally been rewarded by a remarkably good result, as is illustrated by the following example :—

Case 10.—Age 63. Lump noticed in right breast for three years. On examination, above the nipple was a large purplish mass, 8 × 5 cm. in size. In the centre were two dark-blue soft swellings, and around them the growth was hard and the edges red and raised. Skin infiltrated over the whole area. Growth fixed to pectoral fascia. The axilla was almost completely filled by a hard mass, and some small lumps were palpable in the infraclavicular region. Radium treatment given

FIG. 328.—*Case* 10. At time of first treatment.

FIG. 329.—*Case* 10. Nine months after first treatment.

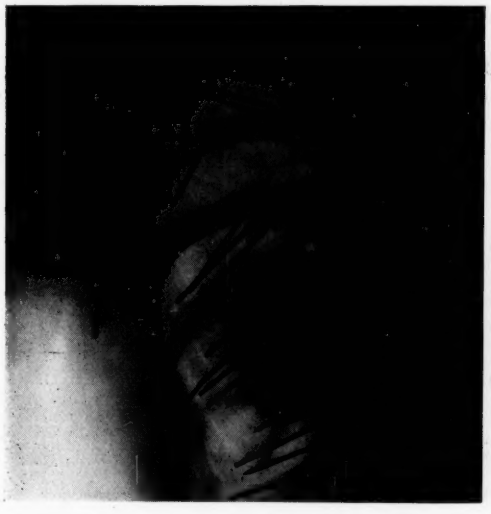

FIG. 330.—*Case* 10. Position of radium needles in first treatment.

FIG. 331.—*Case* 10. Three years after first treatment.

on July 13, 1926, needles being placed deep to the growth to avoid causing necrosis. Section showed spheroidal-celled carcinoma without much connective tissue. The mass continued to shrink for eight months after treatment, and a second treatment was given on May 3, 1927. There was further improvement during the next seven months. Third treatment on Jan. 17, 1928. By March 12 there was no evidence of active disease. A fourth treatment was given on June 7, 1929, for a small recurrent

nodule in the skin, outside the area treated. By Oct. 2 this had disappeared. On July 8, 1930, there was some evidence of recrudescence of growth under the areola, and a surface application of radium was given on Oct. 9. By this date there was a palpable mass in the abdomen, probably an omental metastasis, but the disease has not progressed locally, and the patient feels well (5 years, 2 months). (*Figs.* 328–331.)

Even when the growth has been of massive size it has sometimes disappeared with remarkable rapidity—that is, within three months of treatment; but in other instances a lump of doubtful nature has still remained after five or six months, and it is these that have called for further radium treatment or for local removal. (The evidence derived from these cases is described in detail elsewhere—*see* p. 439).

Fungating growths, which are sometimes also ulcerated, respond well to treatment, and sometimes the ulcer heals within a few weeks, and the growth completely disappears within four or five months. This type of growth, being conspicuous on the surface, lends itself well to illustration, and provides the most easily demonstrable result. Healing of an obvious ulcer has occurred in six patients, including the first patient treated, who has already been described in detail. Occasionally a small crater, surrounded by some remnant of the growth, has persisted and has called for a local excision, but this may be regarded as a satisfactory result in an apparently unfavourable type.

Case 41.—Age 68. Lump noticed in right breast for two years. On examination there was a large ulcerated tumour in the inner upper quadrant, fungating some distance above surface of skin, 6 cm. in diameter. Nipple almost destroyed. Large hard gland in axilla. Radium treatment on June 22, 1928. By Sept. 5 the mass had almost disappeared, but a small ulcer remained in the centre. This was healed by March 5, 1929, but some small nodules remained in the skin. The area of the scar was excised, but the patient died of cerebral hæmorrhage on March 14. Section showed carcinoma cells present beneath the skin.

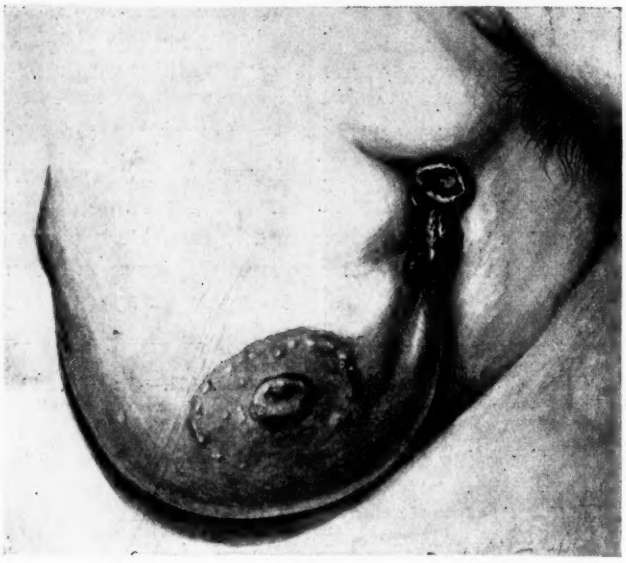

FIG. 332.—*Case* 45. Appearance of tumour before treatment.

Case 45.—Age 40. Lump noticed in left breast for two years. Ulcerated for three months. On examination there was an ulcer, 4 × 5·5 cm., with raised everted edges, and underneath a hard lump, 5 × 6·5 cm., attached to underlying structures. Large gland palpable in left axilla. Inoperable (*Fig.* 332). Radium treatment on

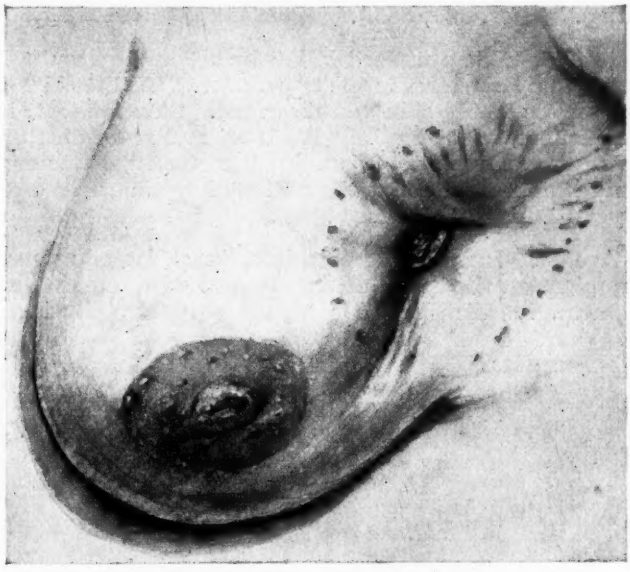

FIG. 333.—*Case* 45. Five months after treatment.

Aug. 23, 1928. The ulcer gradually healed, and four months after treatment the lump in the breast and the axillary gland had disappeared. Five months after treatment the appearance was as in *Fig.* 333. Local condition remained satisfactory, but patient died with spinal metastases on Dec. 16, 1930 (1 year, 8 months).

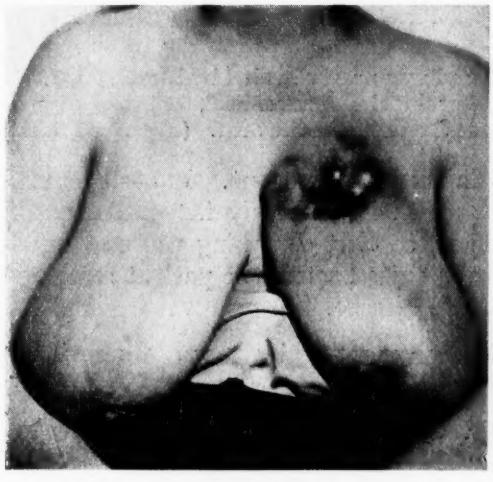

FIG. 334.—*Case* 104. Before treatment.

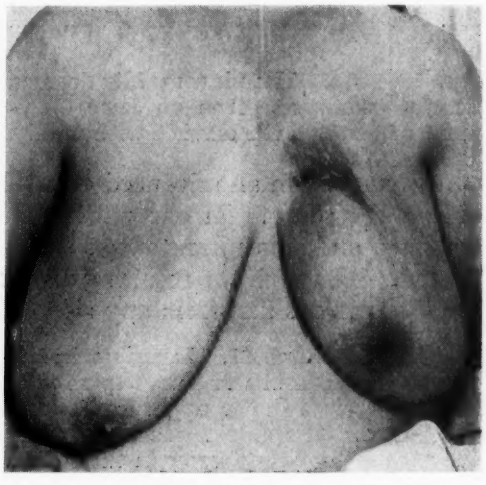

FIG. 335.—*Case* 104. Sixteen months after treatment.

Case 104.—Age 55. Lump noticed in left breast for five years. On examination there was an enormous mass, 13 cm. in diameter, in the upper part of the breast,

fixed to deep fascia and to skin, which was partly ulcerated. Large gland palpable in right axilla. Radium treatment on Feb. 27, 1930. Increase of ulceration followed, but by Aug. 27 it was quite healed, and only a remnant of the tumour remained. A second radium treatment was given on this date. On June 24, 1931, nodules seemed to be developing in the scar, and this residual mass was excised on July 2. The wound has healed well and the patient is without signs of disease at the present time (1 year, 6 months). (*Figs.* 334, 335.).

Case 128.—Age 73. Lump noticed in left breast for two and a half years. On examination there was a large mass in the upper part of the breast, 7 cm. in diameter, raised above the surface of the skin and ulcerated. Skin infiltrated. No enlarged glands felt. Radium treatment on July 17, 1930, and re-needled on Aug. 11. By Dec. 17 the lump was reduced to 3 cm. in diameter, and was excised on Jan. 8, 1931. The wound healed slowly, but the patient is without signs of disease at the present time (1 year, 1 month).

Case 149.—Age 64. Lump noticed in left breast for two years, ulcerated six months. On examination there was a large foul ulcerating mass in the upper half of the breast, 8 cm. in diameter. No glands palpable. Radium treatment on

FIG. 336.—*Case* 149. At time of first treatment.

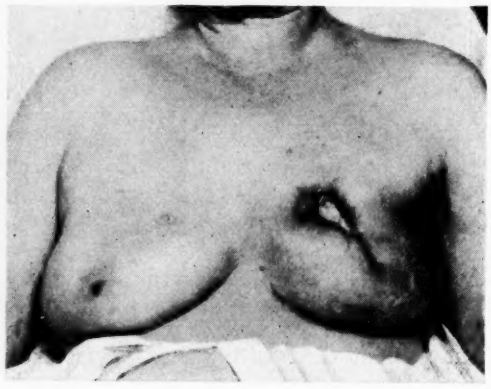

FIG. 337.—*Case* 149. Two months after first treatment.

Jan. 19, 1931. The ulcer rapidly decreased and was nearly healed by March 23, 1931. Second treatment given on June 6. Further local improvement, but the disease increased behind the clavicle with paralysis and œdema of the arm. (*Figs.* 336, 337.)

Sloughing in an advanced growth has been a rare event. It has occurred only three times. In one patient the growth had already invaded a costal cartilage and was ulcerated on the surface, so that sloughing was not unexpected. Although the resulting ulcer never quite healed, the patient remained for long periods free from any sign of active disease.

Case 12.—Age 47. Lump noticed in left breast for twelve years. On examination the left breast was found to be pulled up much higher than the right by a contracting growth in the upper inner quadrant, about 5 cm. in diameter, ulcerated in the centre. The areola was contracted, and there was a nodule in the skin below the nipple. A deep furrow in the skin led outward from the growth to a hard lump in the axilla. Radium treatment on Nov. 19, 1926. Section showed spheroidal-celled carcinoma. On Jan. 13, 1927, the whole area of growth was occupied by a shallow ulcer with a sloughing base. The lump in the axilla had disappeared. The ulceration slowly deepened and was ultimately followed by sloughing of the underlying costal cartilage. On July 20, 1928, a second treatment was given for a nodule

in the skin in the axillary line. This disappeared. On Oct. 25, 1929, a third treatment was given for an enlarged gland in the opposite axilla. On Sept. 3, 1930, cutaneous nodules were appearing on the back, and the patient died on May 25, 1931, with pulmonary metastases (4 years, 6 months).

In another an enormous growth was found, on examination of a section, to be already undergoing spontaneous necrosis. Here, again, it was not unnatural that massive necrosis followed, with eventual healing; the patient remained thereafter free from gross local disease, though she eventually succumbed to skeletal metastases.

Case 39.—Age 39. Lump noticed in left breast for one year. On examination the breast was occupied by an enormous tumour, adherent to the pectoral muscle and to the skin. No enlarged glands detected. Radium treatment on June 8, 1928. Section showed the greater part of the growth to be necrotic, though a few carcinoma cells could be recognized. Sloughing of the whole mass followed the treatment. Healing followed within two months. Second radium treatment given for nodules in the skin on April 19, 1929. Patient developed pulmonary metastases and died in January, 1930 (1 year, 7 months).

In the third patient the radium treatment had been preceded by extensive X-ray treatment (*Case* 29). In the fourth patient the tumour was a flat scirrhous growth.

Case 126.—Age 57. Lump noticed in left breast for one year. On examination the breast was occupied by a hard irregular mass, 5 × 4 cm., fixed to pectoral muscle and to skin, which was red and crusted. No glands palpable. Radium treatment on July 11, 1930. Sloughing of the tumour followed the treatment, and healing was slow. It was almost healed on May 5, 1931, and there are no signs of disease at the present time (1 year, 2 months.)

EFFECT OF IRRADIATION ON GLANDS.

In applying radium treatment to carcinoma in other parts of the body, notably in the tongue and mouth, the effect on the lymphatic glands has been found to be unsatisfactory, and but little progress has been made in this part of the problem during recent years. In treating carcinoma of the breast, on the other hand, I have constantly been surprised at the excellent way in which secondary glands have responded to treatment, and the infrequency with which recurrence in glands has taken place, whether they were previously palpable or not. Since the first few patients were treated, the routine irradiation of the lymphatic areas, as detailed above, has never been omitted. The technique, as I have described it, is not as a rule either difficult or dangerous, though it has naturally met with some criticism. The late G. E. Birkett,[7] for instance, believed that it is impossible to irradiate the axilla accurately by implanting needles through the skin, and he held that it should always be done through a wide incision. With this view, after comparatively long experience, I am in complete disagreement as regards the ordinary patient. If there are palpable glands in the axilla, it is quite easy to surround these accurately with the long needles, and the glands will then usually disappear completely and permanently. If there are no palpable glands, it is not difficult to place needles on the four walls of the axilla in such a way that all the lymph glands will be irradiated, and nothing is to be gained

by open incision. I have never yet injured a nerve or vessel in the axilla. I am willing to admit, however, that there is one type of patient—namely, the very stout woman—in whom the procedure does become difficult, and I would even go so far as to say that for the extreme case of this type, radium treatment is altogether unsuitable, though probably this does not apply to more than 2 per cent of the patients presenting themselves.

Recurrence of disease in axillary glands has been noted in only nine patients, and this, considering the advanced stage of the disease in so many of them, is a remarkable observation. Some surgeons of experience even before the advent of radium treatment were beginning to doubt the wisdom of extensive dissection of the axilla, and the results obtained with radium—the most conservative means of treatment available—tend to confirm this view.

Of the nine patients who did have recurrent disease in the axilla several received further treatment. Three are at present free from signs of disease, and the other six are among those who have died.

As regards the supraclavicular glands, here again it appears to me that accurate needling of the glands is not difficult and is effective. G. E. Birkett appeared to regard the introduction of two needles above the clavicle and two below it as theoretically inadequate. The fact remains, however, that I have noted supraclavicular recurrence in only three patients: one of these after further treatment has no palpable glands anywhere (*Case* 71, p. 452); the other two were in an advanced stage of the disease and have died.

Needles have been introduced into the upper three intercostal spaces chiefly on theoretical grounds. I have never seen recurrence take place in this position, or in the area between the sternum and the breast. Neither have I yet seen recurrence take place in the epigastric region, which I have not been in the habit of treating.

HISTOLOGICAL EVIDENCE OF THE EFFECT OF RADIUM.

As already mentioned, during the earlier stages of this investigation a specimen was removed from the primary growth in order to prove the nature of the disease. This was done in fifty consecutive cases, the specimen being taken when the needles were removed—that is, after the carcinoma had been subjected to irradiation for a period of at least seven days. The histological appearance of the growth was not obviously altered in the specimens thus obtained, even though the growth was destined, in due course, to disappear. Other evidence, however, has been available from specimens removed at much longer intervals after irradiation.

In six patients it was found after the lapse of several months that small hard nodules still remained in the skin or round the rim of a small residual ulcer. It was obvious in these cases that some carcinoma still remained, and a small area was excised locally. In all of these the presence of carcinoma was verified, though in most of them a large or even inoperable tumour had been reduced to small dimensions. Of the six patients, four are without signs of disease, one has no local recurrence but has metastases in bones, and one has died of cerebral hæmorrhage. The history of one of these patients is peculiar:—

Case 21.—Age 61. Lump under left nipple noticed for at least three years. On examination the nipple had disappeared, leaving an ulcerated cleft. Beneath this was a hard mass, 2 × 3 cm. No enlarged glands detected. Operable. Radium treatment on Sept. 20, 1927. By Jan. 31, 1928, the ulcer was almost healed, but a small rim of hard nodules remained around it. The lump beneath had practically gone. On this date the ulcer was locally excised. Section showed, as expected, carcinoma cells immediately surrounding the ulcer. None were discovered deep. Patient has remained locally cured, though a small ulcer of the skin was excised from the axilla on Dec. 5, 1930, which showed localized carcinoma cells, while a lymph gland in close proximity was free. Patient now apparently well (3 years, 11 months).

This specimen showed disappearance of all the deeper portions of the growth after a single radium treatment, and a small local operation has apparently eradicated the disease in the breast. The recurrence in the skin of the axilla can only be explained by supposing that carcinoma was present in the axillary glands at the time of the first treatment, and that a cancer cell was transplanted into the skin. This is the only occasion on which such an event has been noted.

In eighteen other patients a firm mass has remained in the breast even after two treatments. Owing to the uncertainty as to the nature of these masses the breast has been removed, or a portion of it excised, and this material has furnished important evidence as to the effect of the treatment.

Case 9.—Age 60. Lump noticed in left breast for six months. On examination there was a firm lump, 2 cm. in diameter, freely movable. No other signs of disease. The diagnosis was doubtful and the lump was excised locally. It was found to be a localized mass of carcinoma, and radium treatment was given immediately after the operation on May 18, 1926. Eleven months later the growth recurred, and a second treatment was given on April 28, 1927. The lump did not completely disappear, and it was excised on Sept. 23, 1927. A section through the centre of the mass showed fibrous tissue only, and no trace of carcinoma could be found (*Fig.* 338). No local recurrence took place, but the patient died on Oct. 1, 1930, with intrathoracic metastases (4 years, 5 months).

Case 14.—Age 56. Lump present in the left breast for at least three years. On examination the upper part of the breast was found to contain a large mass, 5 × 4 cm. and very thick. Skin infiltrated with a shiny reddish mass projecting some distance above the surface. Mass fixed to pectoral fascia. No enlarged glands detected. Inoperable. Radium treatments on Feb. 10 and June 8, 1927. Very great reduction in the size of the mass followed, and the boss on the surface completely disappeared. On Nov. 1 a hard residual lump, 3 × 3 cm., remained, covered by apparently normal skin. Lump removed on this date by a local excision of tissues down to the ribs. Healing by first intention. Section removed on Feb. 16, 1927, showed spheroidal-celled carcinoma with much fibrous tissue. Sections of the residual lump showed that it consisted almost wholly of fibrous connective tissue. On the surface of the mass just under the epidermis—that is, at the farthest point from the radium needles—a thin layer of carcinoma cells remained (*Fig.* 339). Patient remained free from any local recurrence in breast or glands until April 27, 1931, when she died of spinal metastases (4 years, 2 months).

This section appeared to demonstrate conclusively that a very thick mass of growth had been sterilized of carcinoma by two radium treatments, except for a thin layer on the surface, which could have been treated by superficial application. The patient remained locally free from recurrence after excision.

Case 22.—Age 61. Lump noticed in right breast for five months. On examination the upper outer part of the breast contained a mass, 3 cm. in diameter, visible on surface, attached to skin. No enlarged glands detected. Operable. Radium treatment on Oct. 25, 1927. Section removed on Nov. 1 showed spheroidal-celled carcinoma. By April 3, 1928, the original mass had completely disappeared. On April 9, 1929, there was apparently a recurrence in the same situation. Second

radium treatment given on June 28. By Nov. 5 the mass was somewhat smaller, but stationary. Some deep X-ray treatment given on Dec. 19. Lump remained almost unaltered, and the breast was locally removed on July 3, 1930.

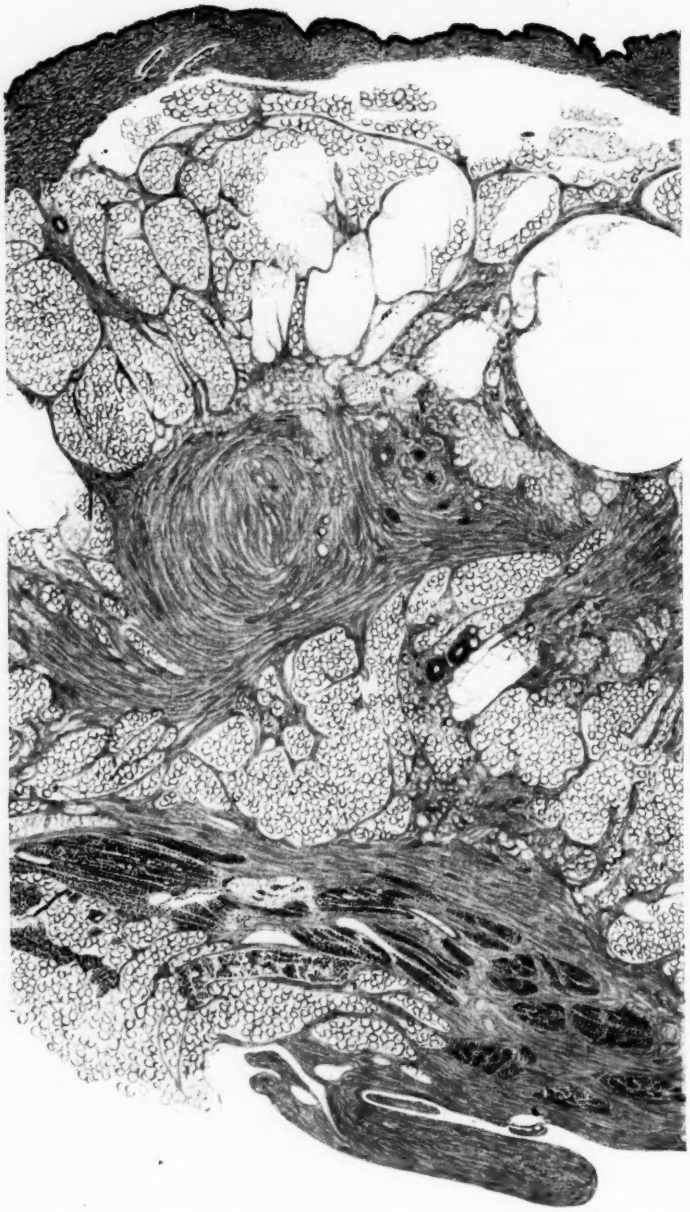

FIG. 338.—*Case* 9. Section through area of growth seven months after second treatment. No carcinoma found.

Careful examination of the specimen failed to show any carcinoma cells anywhere. It is possible that the second radium treatment and X-ray treatment were really superfluous. The patient remains quite well to the present time (3 years, 10 months).

Case 38.—Age 77. The right breast contained a large mass, 7 cm. in diameter, at least 3 cm. thick. Attached to the skin over a wide area, but not to deep fascia. No enlarged glands detected. Radium treatment on June 1, 1928. Section showed spheroidal-celled carcinoma. On Nov. 19 a lump remained, but only half the size of

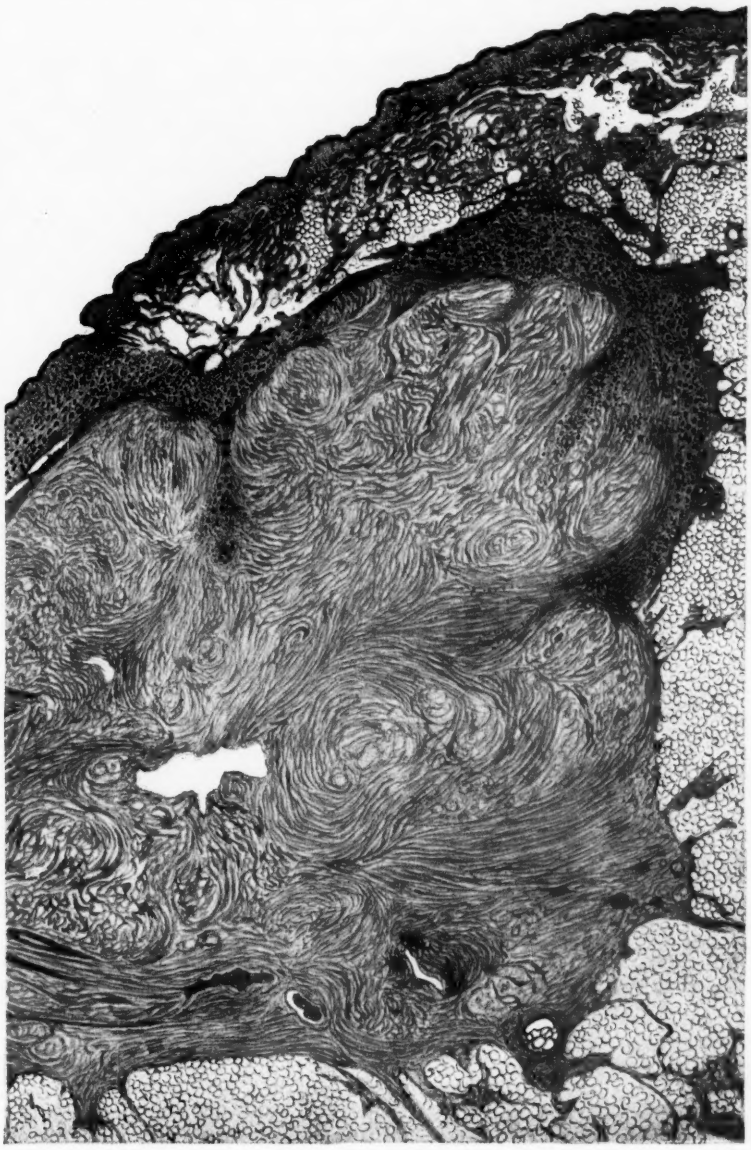

FIG. 339.—*Case* 14. Section through residual mass six months after second treatment. Carcinoma cells found subcutaneously only.

the original mass. This was locally excised on Dec. 7, and the patient has remained free from disease since that time (3 years, 3 months).

On careful examination of the specimen removed no trace of carcinoma could be discovered. The residual mass consisted entirely of fibrous tissue (*Fig.* 340).

Case 42.—Age 58. Lump noticed in right breast for two years. On examination, found to have a large swelling, 6 cm. in diameter, in upper inner quadrant of breast, fixed to skin and pectoral fascia. Hard enlarged gland, 2 cm. in diameter, in right axilla. Operable. Radium treatment on June 26, 1928. Section showed spheroidal-celled carcinoma. By Jan. 30, 1929, both the lump in the breast and the enlarged gland had completely disappeared. On July 16, 1929, a recurrence was detected

FIG. 340.—*Case* 38. Section through site of massive growth six months after treatment. No carcinoma found.

between the breast and the axilla in an untreated area. Second radium treatment given on Aug. 1. On Nov. 5 patient appeared to be still not free from disease, and the breast was removed locally on Nov. 21. Examination of the specimen showed no sign of carcinoma in the area originally treated. A few isolated carcinoma cells were found at the edge of the specimen. Patient has remained without recurrence since (3 years, 2 months).

The specimen showed almost complete sterilization of the breast, but in this instance the error had been made of not treating the breast and axilla in continuity, recurrence taking place in the interval between them.

Case 54.—Age 57. Lump in right breast noticed for four months. On examination, in outer part of the breast was a tumour, 3 cm. in diameter, attached to nipple. Hard enlarged gland in right axilla. Operable. Radium treatment on March 1, 1929. By July 16 no tumour or glands remained. On May 6, 1930, some evidence of recurrent growth detected. Local removal of breast on July 10. Patient has remained free from disease since (2 years, 6 months).

Examination of the specimen showed a small localized area of carcinoma in the centre of the breast. Otherwise free from disease.

Case 76.—Age 50. In the left breast was a large mass, 8 cm. in diameter, occupying the greater part of the gland. Attached to the skin. Nipple retracted. No enlarged glands detected. Radium treatment on July 19, 1929. On Jan. 9, 1930, a small residual lump was still present, and a second radium treatment was given. The lump became somewhat smaller, but was still present on Sept. 29, when the breast was locally removed. The patient is now without signs of disease (2 years, 1 month).

On examination of the breast no trace of carcinoma could be found. The residual lump appeared to be due to a small patch of fibrosis and fat necrosis.

Case 79.—Age 55. Lump noticed in right breast for six months. There was a large indefinite tumour, about 6 cm. in diameter, beneath the nipple, which was retracted. Slight patchy discoloration of the skin. No enlarged glands palpable. Operable. Radium treatment on Aug. 28, 1929. By Dec. 10 no tumour was palpable, and the nipple was almost normal. On Feb. 26, 1930, it was noticed that one of the small patches on the skin was slightly thicker than before. The breast was

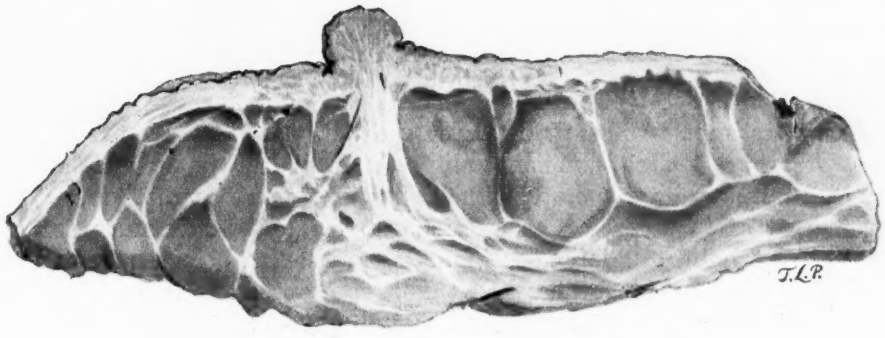

FIG. 341.—*Case* 79. Slice through breast eight months after treatment for a massive carcinoma.

removed locally on May 1. In September, a precautionary surface application was given to the right side of the chest. The patient now has signs of thoracic metastases (September, 1931).

The examination of the specimen gave interesting results. The large mass previously present had completely disappeared, so that a slice through the breast looked quite normal (*Fig.* 341). No trace of carcinoma could be found anywhere in the breast. A section through the small patch in the skin showed, however, carcinoma cells present in the dermis in this area. Presumably, therefore, the disease could have been completely eradicated by a superficial application after the interstitial irradiation.

Case 82.—Age 42. Lump noticed in left breast for a few days. On examination the left nipple was found to be slightly elevated and retracted. There was a large hard lump in the upper part of the breast, about 7 cm. in diameter, attached to the

nipple, but not to the skin or deep fascia. Operable. Radium treatment on Sept. 10, 1929. By Nov. 5 the breast was quite soft and no tumour remained. On Oct. 1, 1930, it was noticed that there was some thickening to be felt on the deep surface of the breast in its upper part. The breast was removed locally on Oct. 30. The patient is at present without signs of disease (2 years).

Examination of the specimen showed no sign of carcinoma anywhere, the thickening being due to fibrosis only.

Case 106.—Age 49. Lump noticed in right breast for six months. There was an elongated hard mass extending from one side of the breast to the other, at least 8 cm. long. Nipple retracted, and skin dimpled on outer side. No enlarged glands detected. Operable. Radium treatment on March 7, 1930. By Sept. 10 the breast was quite soft, though there remained some soreness of the nipple. This afterwards increased, and there appeared to be a small lump beneath the nipple. The breast was removed locally on Nov. 25. The patient is free from disease at the present time (1 year 6 months).

Examination of the specimen showed active carcinoma cells immediately beneath the nipple.

Case 111.—Age 50. Both breasts very large. Lump noticed in upper part of right breast for one month. On examination the right nipple was found slightly elevated, but not retracted. In the upper outer quadrant was a very large mass, about 7 × 5 cm. in diameter, and very thick. Two hard glands felt in right axilla. Operable. Radium treatment on April 11, 1930. Left breast removed at same time owing to its weight. By July 8, no tumour could be felt and no glands were palpable. Right breast removed on Feb. 6, 1931, although no recurrence detected, owing to the large size both of the breast itself and of the original tumour. In the site of the growth on the deep surface of the breast was found a small carcinomatous area, 1·5 cm. in diameter. No other evidence of disease found. A very large growth had, therefore, been almost, but not quite, eradicated by a single treatment. The patient is quite well at the present time (1 year, 5 months).

The evidence obtained from these eighteen patients is on the whole a satisfactory testimony to the powers of radium. Admittedly, the necessity for removal argues that radium is not all-powerful or that the present technique is at fault. Infallibility is not claimed, however, for the method, and the fact remains that in 7 of the 18 specimens no residual carcinoma was found. In 9 of the remaining 11 a large carcinomatous mass had been reduced to small dimensions. In only 2 instances had the disease spread widely after irradiation. It is of interest to notice that, although nearly all the patients were in an advanced stage of the disease and would be looked upon unfavourably as regards prognosis, they do not appear to have lost by the method of treatment that was used. Of the 18 patients, 17 are alive, and 14 of them are without any signs of disease at the present time—that is, for periods up to 3 years, 9 months. One patient died of the disease, one has skeletal metastases, one thoracic metastases, and one metastases in the skin. Removal of the breast after irradiation appears therefore to be a legitimate method of combining radium treatment with surgery.

CLINICAL EVIDENCE OF CURE.

In assessing the results of radium treatment of carcinoma of the breast I have consistently tried to avoid using the word 'cure' without qualifications. Sometimes, when all signs of disease have disappeared, I have said that the patient was 'apparently cured', being aware that in this disease recurrences

have been known to appear after the lapse of fifteen or even twenty years after surgical treatment. At other times, so sceptical have I been, that I have stated that there is no such thing as 'cure' in this disease, the patient being liable to develop recurrences for the remainder of her days. Never-

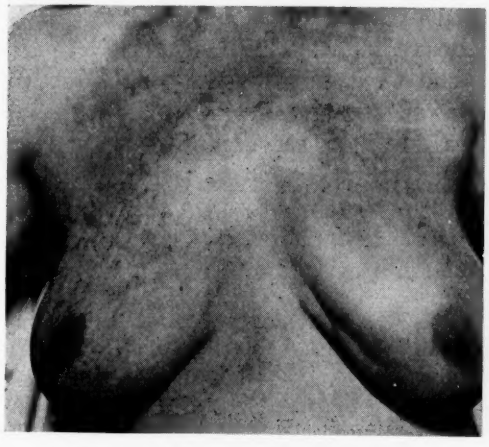

FIG. 342.—*Case* 23. Before treatment.

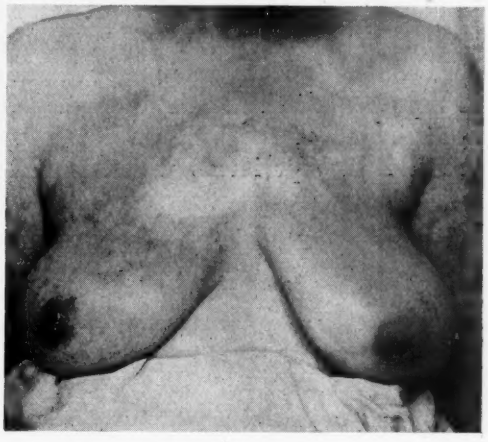

FIG. 343.—*Case* 23. Three years after treatment.

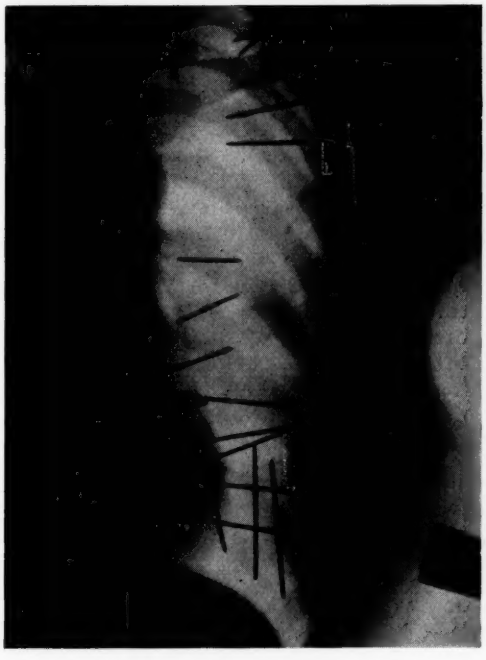

Fig. 344.—*Case* 23. Position of radium needles.

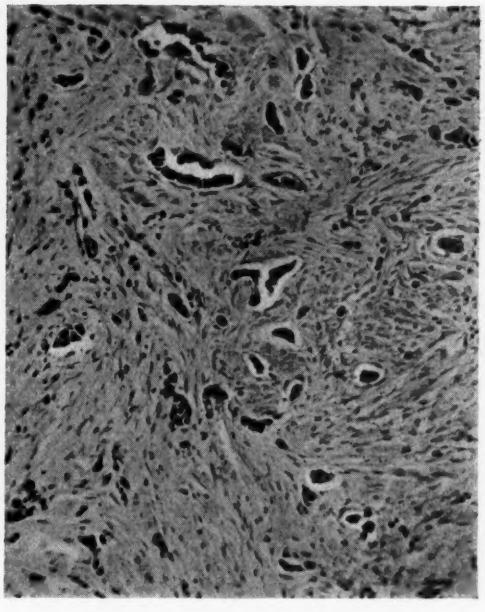

FIG. 345.—*Case* 23. Section showing fibrous tissue with spheroidal-celled carcinoma.

theless, the histological evidence adduced above, seems to show that 'local cure' can be produced by radium, careful investigation being unable to detect any evidence of carcinoma cells remaining. But no pathological investigation can be minute enough to *prove* that no isolated cells or clumps of cells

remain in the tissue. Some other proof of cure must therefore be sought, and I believe that this may be founded on a physiological basis. The extreme malignancy of carcinoma of the breast when associated with pregnancy or lactation is well known; it is shown by the increased rapidity of growth of the primary tumour and by the unusually quick appearance of metastases in other parts of the body. It is believed that these phenomena are due to local hyperæmia in the breast, and to the profound stimulus applied to the epithelial cells of the mammary gland by the hormone from the corpus luteum in the circulation. If these circumstances were to arise in a woman who had a carcinoma of the breast treated by radium, the stage would be set for the clinical experiment which would apply the severest test possible to the efficacy of the treatment. Actually these circumstances have arisen in the following instance:—

FIG. 346.—*Case* 23. Three years after treatment.

Case 23. Age 44. Small lump noticed in inner part of left breast for two years. On examination, a hard mobile lump, 3 cm. in diameter, was felt in the inner half of the breast, attached to the skin, which was puckered (*Fig.* 342). Nipple slightly elevated. No enlarged glands detected. Operable. Radium treatment on Oct. 25, 1927. Specimen removed for section showed spheroidal-celled carcinoma with proliferation of epithelium in neighbouring acini. By Feb. 13, 1928, the tumour had disappeared, leaving a small area of thickening. In December the patient became pregnant and was seen five months later. There were no signs of recurrence, and the pregnancy was allowed to proceed to term. The child was fed at both breasts, the left breast lactating normally. There has been no sign of recurrence of the disease, and the patient is quite well at the present time (3 years, 10 months). (*Figs.* 342–346.)

The history of this patient seems to be as nearly a *proof* that carcinoma of the breast can be cured by a single treatment with radium as can be attained—better evidence even than the passage of twenty-five years after the treatment, for a supposed local recurrence after this interval might really be another independent growth.

Up to the present time this combination of circumstances has not occurred in a second patient. Another woman, age 38, reported to me eighteen months after an apparently quite successful treatment of a small and early carcinoma in the axillary tail of the right breast, with an enlarged gland in the axilla, that she had missed one period. There was no change in the breast, but I felt it my duty in the present state of knowledge to advise that the pregnancy be terminated.

Case 89.—Age 37. Lump noticed in the axillary tail of right breast for a short time. On examination, a small, hard, mobile lump, 2 × 1·5 cm. in diameter, in the axillary tail, not attached to skin or fascia. Fairly large gland palpable in the right axilla and some smaller ones just palpable. Radium treatment on March 1, 1929. By June 12 no trace of the lump remained and the breast felt quite normal. No glands palpable. On Sept. 16, 1930, the patient consulted me because she had found herself to be pregnant. The pregnancy was terminated immediately. The patient has remained quite well since (2 years, 6 months).

FAILURES.

Radium treatment is a form of local treatment, and failure to achieve local extirpation of the disease is therefore the only kind of failure that need now be considered. The possibility that dissemination may be actually stimulated by radium is discussed elsewhere (p. 458). Failure interpreted in this sense may be of several types, which will be considered separately.

1. The disease may recur actually *within the area treated or in close proximity to it*, and in such cases complete failure to control the disease may have to be admitted. Sometimes, as has also been recorded by other observers, there may be at first such striking improvement that the tumour may disappear completely and the breast become almost normal. Then recurrence takes place, and the fresh growth may progress very rapidly. Complete failure of this kind I have registered in five instances. In one of these the dose given was undoubtedly inadequate, the time having been only four days instead of the usual seven.

Case 50.—Age 39. Lump noticed in right breast for one year. On examination a hard irregular mass beneath areola was felt, 5 cm. in diameter and 3 cm. thick. Skin adherent and thickened. Nipple retracted. No palpable glands. Radium treatment on Feb. 5, 1929, and owing to fear of sloughing taking place, the needles were removed at the end of four days. Regression of tumour was rapid, though there was some œdema of the skin remaining on May 7. Two months later the breast was again found to be occupied by a large tumour. A second radium treatment was given on Aug. 5. The tumour again regressed, but the patient showed signs a month later of thoracic and spinal metastases, and she died on April 8, 1930.

In one the breast was extremely fat, a type of patient which I have discussed elsewhere, and the extent of the disease when treatment was begun was greatly underestimated.

Case 53.—Age 47. Lump noticed in left breast for one year, and treated by local injections by Dr. Shaw Mackenzie. On examination a hard lump was felt on the outer side of the left breast, of at least 4 cm. diameter, but difficult to estimate owing to the very large size of the breast. The skin was beginning to be dimpled, and a hard gland could be felt in the axilla. Radium treatment given on Feb. 20, 1929. On June 5 the greater part of the lump had disappeared, but some irregularity remained in the upper part of the breast. The axillary gland was smaller. On Sept. 24 the disease was obviously extending, and the breast was removed. Deep X-ray treatment was also given, but the patient died on June 21, 1930 (1 year, 4 months).

In one (*Case* 9) an injudicious local excision was done before treatment, which was otherwise unsatisfactory. In only two cases (*Cases* 13 and 32) was the failure complete.

Case 32.—Age 47. Lump noticed in right breast for nine months. On examination a hard lump was felt in the right breast, 4 cm. diameter, attached to skin. Enlarged glands palpable in axilla. Radium treatment given on April 18, 1928, for 9 days. A specimen was removed for section in my absence, through a very deep and long incision, which may have prejudiced the result. On June 5 the lump was smaller, but was increasing again under the incision scar by July 3. A second treatment was given on Jan. 18, 1929, after which the growth did not increase for three months. By May 7 it was again increasing. Deep X-ray treatment was given without benefit, and the patient died with generalized metastases in October, 1930.

Case 13.—Age 51. Dimpling of the skin on the outer side of the right breast noticed for eleven months. On examination a hard mass, 8 cm. in diameter, was felt in the outer half of the breast, with retraction of the nipple and adhesion of the skin. Hard gland felt in right axilla. Radium treatment given on Dec. 21, 1926. Section showed spheroidal-celled carcinoma. By March 7, 1927, the tumour and axillary gland had disappeared, though some indefinite thickening remained in the breast. On Sept. 12 two nodules had appeared in the skin on the mesial side of the area previously treated. Second radium treatment given on Sept. 29, followed by disappearance of the nodules. On Jan. 9, 1928, a new lump had appeared between the two areas treated. A local excision of breast showed active carcinoma in the last lump, and some groups of carcinoma cells at the edge of the first area treated. The wound healed slowly and developed a streptococcal infection after the patient had left hospital, and she died on Feb. 18. Post-mortem examination showed no evidence of carcinoma in the chest wall, glands containing carcinoma in the left axilla, above both clavicles, and along the left side of the abdominal aorta.

Much has been written of varying radio-sensitivity in different types of growth in the breast. Such variations certainly do exist, but so seldom is a tumour really insensitive that I have not attempted any 'grading' of the tumours. In the following instance there appeared to be an unusual degree of insensitivity, the breast and the tumour both being small, and therefore easy to irradiate.

Case 78.—Age 46. Lump noticed in left breast for six weeks. On examination there was a prominent swelling immediately above the nipple, 6 cm. in diameter, apparently partly cystic. No glands detected. Radium treatment on Jan. 18, 1929. By March 5 the lump had almost disappeared. On Sept. 6 the swelling was found to have reappeared and was almost exactly as before treatment. It was locally excised, and the specimen showed a cyst with many active carcinoma cells in the wall. On April 10, 1931, the patient was found to have a second tumour similar to the first. The remainder of the mammary gland was removed together with the lower axillary lymphatic glands. The specimen showed a carcinomatous cyst exactly like the first. The lymphatic glands were free from disease. The patient is quite well at the present time (2 years, 7 months).

In this instance a carcinoma of a somewhat unusual type appeared to have been almost unaffected by the radium, the second carcinomatous nodule having appeared within the area treated.

2. The disease may recur *outside the area treated*. This form of failure has been registered in nine patients, and the lesson to be learned from it is obvious.

Case 51.—Age 43. Small lump noticed in left breast for two months. On examination, slight flattening was found at the lower margin of the breast, which was somewhat pendulous and very large. The nipple was slightly retracted. One

gland palpable in left axilla. Radium treatment given on Feb. 9, 1929. Treatment was given only to the lower half of the breast, and to the subpectoral region, axilla, etc., a large gap being left in the upper portion of the breast, which appeared to be free from disease. There was evidence of a diffuse extension of the disease in this untreated part of the breast on Sept. 12, 1930, 1 year and 7 months after the initial treatment. Removal of the breast was advised, but the patient refused. A second radium treatment was given on Sept. 19. By Dec. 2 great improvement had taken place, but soon afterwards the disease recurred extensively throughout the breast. The breast and axillary glands were removed on June 19, 1931, and deep X-ray therapy was given to a wide area surrounding. The patient appears to be quite well at the present time (2 years, 7 months).

Case 75.—Age 60. Lump noticed in right breast for three weeks. On examination there was a hard lump in the outer half of the breast, 3 cm. in diameter, attached to the skin, which was slightly dimpled. Gland palpable in lower part of axilla, but not hard. Radium treatment given on July 11, 1929. The tumour had disappeared and the breast felt quite normal by Sept. 7. No gland palpable in axilla. On Feb. 16, 1930, some thickening in the untreated part of the breast was noted. This had increased two months later, and a local removal of the breast was done on April 23 instead of giving a second radium treatment.

On examination of the specimen the part of the breast treated was found to be free from disease, but carcinoma was found in the outer area. Following removal of the breast radium was inserted under the whole of the area of operation. There has been no local recurrence, but the patient has signs of thoracic metastases.

Case 112.—Age 57. Lump in left breast noticed for one year. On examination a hard mass felt in the inner upper quadrant about $5 \times 7{\cdot}5$ cm. Skin dimpled over it. Nipple slightly retracted and deviated. No glands palpable. Patient very stout and breast very large. Radium treatment on April 10, 1930. By Aug. 27 the mass had almost gone. On Oct. 15 there was found to be evidence of extension of the disease near the nipple in an untreated area. A gland could also be felt in the axilla. Second radium treatment on Oct. 23, 64 mgrm. being used for the breast, whereas only 42 mgrm. were used on the first occasion. By March 11, 1931, no sign of local disease could be discovered, but the patient now has pelvic metastases.

These examples illustrate the fact that it is easy to concentrate attention too much upon the main mass of growth, and to forget that secondary dissemination occurs *within* the mammary gland as well as outside it, as already mentioned. Although I have always aimed at treating a considerably larger area of breast than is occupied by the palpable tumour, I have sometimes failed to carry this far enough, and latterly I have practised a wider distribution of the radium than before. Properly the whole breast and the underlying fascia should be treated as a routine, and except in the largest breasts this is being carried out at the present time. It is partly for this reason that I have so much emphasized the importance in technique of using the longest needles and placing them largely beneath the breast. Only in this way can the requisite area of breast and fascial planes be adequately treated. If the breast is not very thick, this distribution will irradiate the tumour as well as the breast. If the breast is a thick one, it may be necessary to insert additional needles more superficially in the neighbourhood of the growth.

Further than this, it is of some importance to remember the main lymph channels which run round the outer border of the pectoralis major muscle on their way to the axillary glands. Examination of the X-ray records of

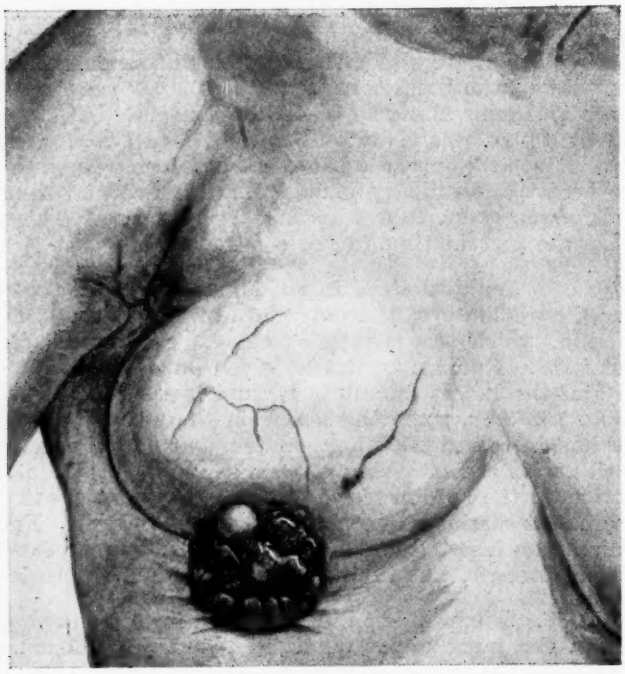

FIG. 347.—*Case* 27. Appearance of tumour before treatment.

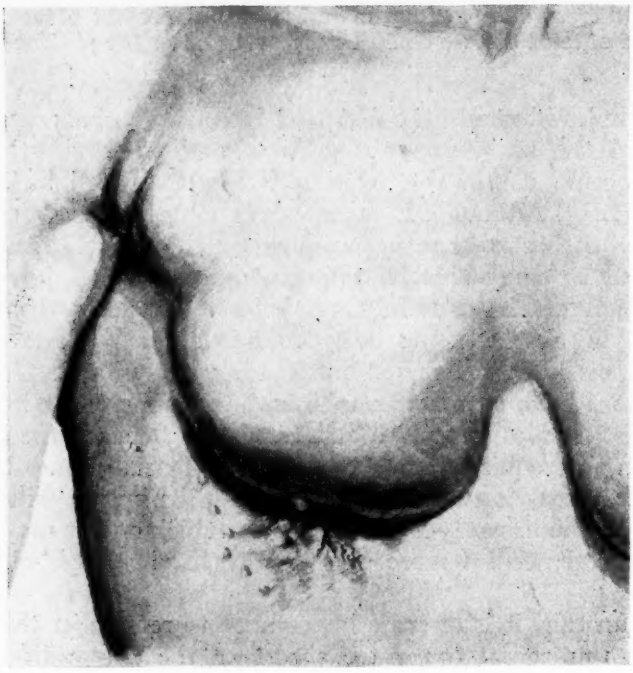

FIG. 348.—*Case* 27. One year after treatment.

my earlier patients shows that I have sometimes been guilty of leaving this 'pectoral gap' between the breast and the axilla untreated. Retribution has occasionally followed, for in two patients recurrence has taken place exactly in this untreated gap. The needles should therefore be inserted in unbroken series from the breast to the upper axilla.

Case 27.—Age 62. Lump noticed in the right breast for five years. On examination the right breast was elevated and smaller than the left. Nipple retracted. In the inner lower quadrant was a bright-red area, the centre covered with a crust, diameter about 5 cm. (*Fig.* 347). A hard mass, 3 × 2 cm., extended from the ulcer towards the axilla. Several small glands palpable in axilla. Radium treatment given on Dec. 16, 1927. Section removed on Dec. 22 showed spheroidal-celled carcinoma (*Fig.* 350.) The main mass of growth disappeared in the course of

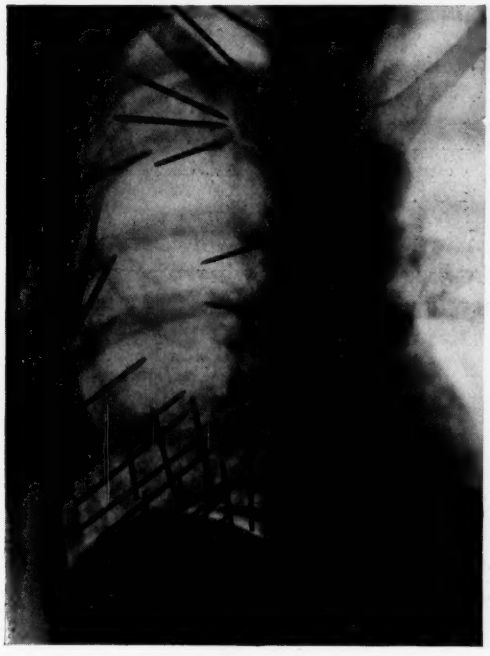

FIG. 349.—*Case* 27. Position of radium needles at first treatment.

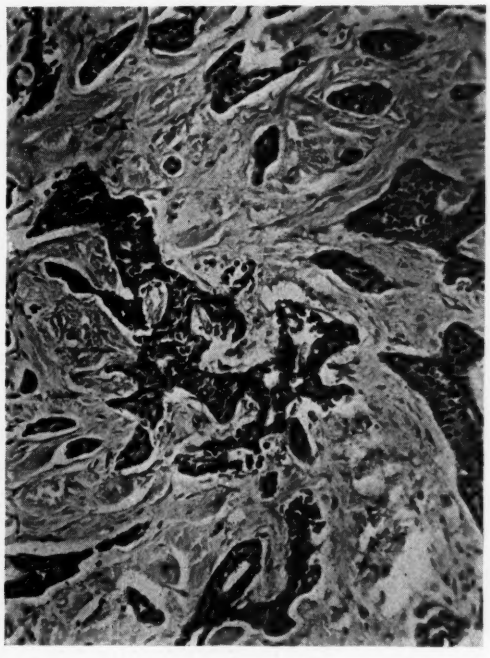

FIG. 350.—*Case* 27. Section showing spheroidal-celled carcinoma.

seven months, and healing was found to be complete by July 18, 1928. A tiny nodule remained which eventually disappeared, and on Jan. 11, 1930, there were no discoverable signs of disease. Needles had been placed under the pectoral muscle (*Fig.* 349), but between these and the needles under the breast a gap was left, and exactly in this position a recurrent nodule was found on Sept. 3. A second radium treatment was given on Oct. 3 to the whole tract from the upper part of the breast to the axilla. On March 3, 1931, the nodule had disappeared, and the patient has remained free from disease since that date (3 years, 8 months).

A second instance of recurrence in the pectoral gap was *Case* 42, already described in detail on p. 442.

3. A third form of failure is shown by the appearance of numerous *skin nodules within the area treated.* This event has been rare, having been seen only in two patients, but its occasional occurrence is an argument in favour

of Cade's method of supplementing interstitial irradiation by surface treatment.

Case 34.—Age 68. A dimpling noticed in the skin of the left breast for two years. On examination the left breast was elevated and the skin drawn in several places. Nipple retracted. The whole of the upper part of the breast was occupied by an irregular mass, about 7 cm. in diameter, attached to the deep fascia. Glands palpable in left axilla. Radium treatment on March 27, 1928. Section removed on May 4, showed spheroidal-celled carcinoma. By Nov. 14 the whole of the original mass had disappeared, but there were nodules in the skin below and to the inner and outer sides. The whole area was treated by a second insertion of needles on Jan. 4, 1929. Two months later all the nodules had disappeared, and there was no local evidence of disease. The patient died on April 4, 1930, of spinal metastases.

Case 70.—Age 60. Thickening noticed in right breast for several weeks. On examination the nipple was retracted and the skin puckered below it. A hard diffuse mass occupied the greater part of the breast, about 6 cm. in diameter. No palpable glands. Radium treatment on June 18, 1929. By Sept. 7 no tumour could be detected. A year later a widely spread crop of skin nodules had appeared over the breast, and the patient had also been having signs of pulmonary metastases. A surface application of radium was given to the area affected, but the patient died with evidence of widespread metastases on Nov. 27, 1930.

4. The fourth type of failure is seen in those patients who return, after treatment, with *enlarged glands in the axilla*, either following disappearance of glands previously enlarged, or as a new event. My technique for treating the axilla has met with some criticism, as already mentioned, but the answer to this is the remarkable effect almost always obtained when the glands are already enlarged, and the rarity of recurrence. This event has been noted only in 9 patients, but when it occurs it is of serious import, 6 of these patients having died. The appearance of glands above the clavicle is even rarer. It has been noted in only 3 patients, in 1 of whom the glands have disappeared after further treatment.

Case 71.—Age 67. Lump in the left breast noticed for six weeks, in inner lower quadrant, 5 cm. in diameter. Attached to skin, with enlarged glands in the axilla. Radium treatment given on June 21, 1929. Three months later the tumour in the breast had disappeared: one soft gland still palpable in the axilla. On June 5, 1930, one year after treatment, there was no sign of recurrence in the breast, but enlarged glands were present in the axilla and above the clavicle. Further treatment was at first considered useless, but two months later the patient was still without other signs of metastases, and a second radium treatment was given on Sept. 2 to the breast and gland areas. By Nov. 21 all enlarged glands had disappeared, and the patient still seems to be quite well (2 years, 2 months).

OVERDOSE.

As already suggested, the dosage employed in this form of radium treatment has been arrived at by somewhat empirical methods. It has thus happened that, during the earlier stages of acquiring experience, the dose has occasionally been excessive, either by reason of too great local concentration of the radium, or as the result of ill-judged zeal in dealing with apparent failures. A dose that was too great at the initial treatment is illustrated by the following case:—

Case 7.—Age 57. Lump noticed in left breast for four years. On examination there was a hard tumour filling the breast, with a prominent lump near the areola; skin over this red and glazed. Nodules in the skin in inner part of breast and over the sternum. An enlarged gland palpable in axilla. Radium treatment given on

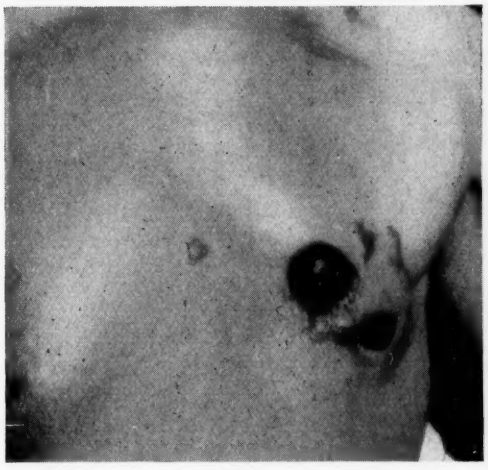

FIG. 351.—*Case* 7. Before treatment.

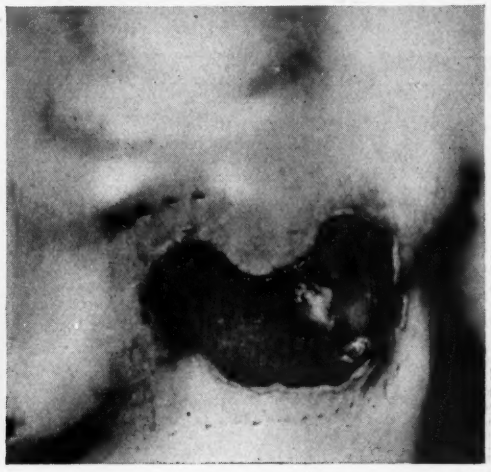

FIG. 352.—*Case* 7. Radium burn seven weeks after treatment.

Aug. 12, 1925, a total of 79 mgrm. being inserted beneath the breast and its neighbourhood for 7 days. The treatment was followed by a very severe radium burn, with late necrosis of the primary growth. The ulcer never quite healed, and skin nodules afterwards appeared outside the area treated. The patient died nine months after treatment. (*Figs.* 351–353.)

FIG. 353.—*Case* 7. Position of radium needles at first treatment.

Instances of injudicious second treatments are given by the following:—

Case 16.—Age 62. Lump noticed in right breast for three months. On examination there was a very hard lump, 6 cm. in diameter, in the inner upper quadrant, with dimpling of the skin. An enlarged gland palpable in right axilla. Radium treatment on April 14, 1927, a total of 51·5 mgrm. being applied to the breast in two layers. Three months later the tumour seemed to have disappeared, but the breast had undergone a remarkable degree of shrinkage. One year after treatment the patient was thought to have a recurrence in the upper part of the breast. This may have been due only to fibrosis, but a second treatment was given on April 12, 1928, 48 mgrm. being applied to the breast in two layers for 8 days. Further shrinkage took place, and late radium necrosis began two years after the second

treatment. The necrosis extended into the axilla, and very deeply into the chest wall. The patient suffered great pain, and died on Jan. 16, 1931, without definite evidence of recurrence of the carcinoma anywhere.

Case 31.—Age 58. Lump noticed in right breast for fifteen months. On examination a large spherical tumour, 6 cm. in diameter, was felt in the upper outer

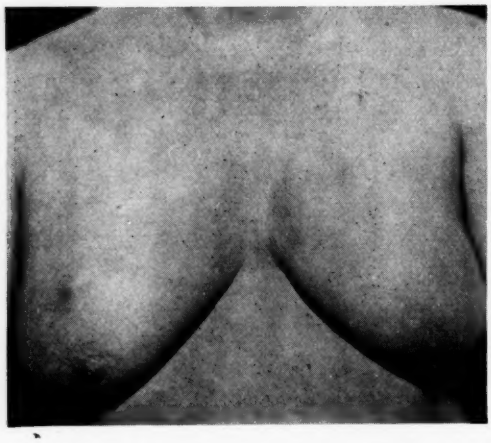

FIG. 354.—*Case* 31. Before treatment.

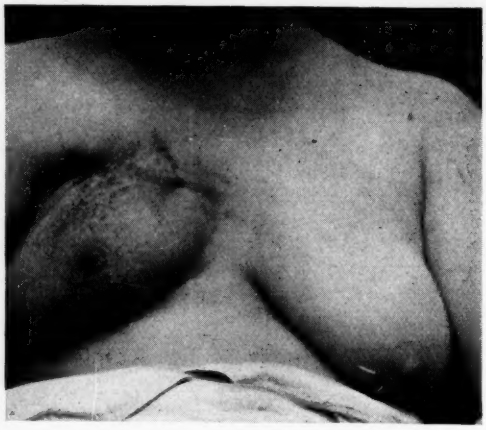

FIG. 355.—*Case* 31. Sixteen months after first treatment.

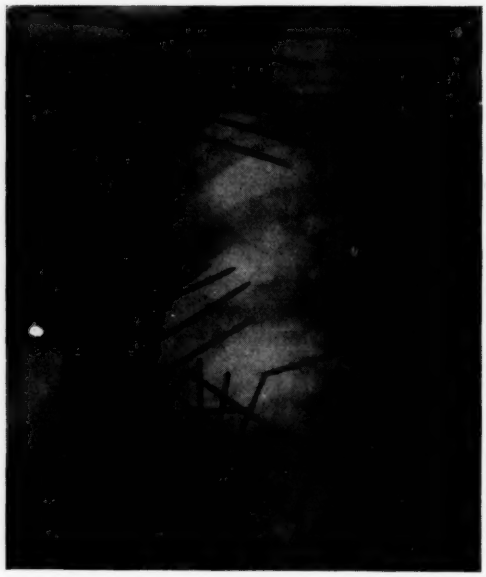

FIG. 356.—*Case* 31. Position of needles at first treatment.

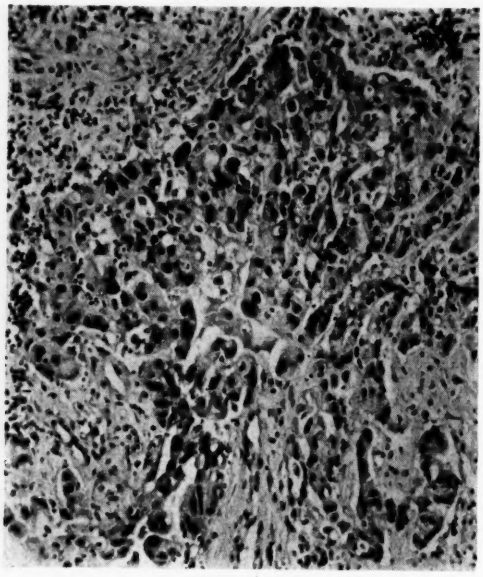

FIG. 357.—*Case* 31. Microscopic appearances of growth.

quadrant, attached to the skin. No glands felt. Radium treatment on March 30, 1928, 54 mgrm. being applied beneath the breast for eleven days. Some contraction followed, and a hard mass remained five months later, which probably consisted of fibrosis only. A second treatment, however, was given on Sept. 4, 1928. Further

contraction followed this, and there was considerable interference with the movements of the right arm. No recurrence took place locally, but the patient died on May 10, 1931, of a malignant ovarian tumour. (*Figs.* 354–357.)

It will be noticed that all these patients were in an advanced stage of the disease. In two the primary growth was big and enlarged axillary glands were present; in one, although no glands could be felt, the tumour was very large. Probably, therefore, special efforts were made to deal with the disease, and in the second and third instances the fibrous contraction which followed the treatment may have been misinterpreted.

ACCIDENTS.

A theoretical objection to radium treatment in the minds of some people has been the supposed risk of injury to important structures, but, assuming that the operator possesses adequate knowledge and exercises due care, this risk appears to have been somewhat exaggerated. Needles should always be implanted with regard to the known position of vessels, nerves, etc., and no force should be used. If they are entering the right plane, very little resistance is to be met; if resistance is encountered, the needle should be withdrawn and re-inserted. Among the 171 patients I have treated no one has suffered injury to a vessel or a nerve in the axilla. In one patient (*Case* 1) a needle inserted above the clavicle appeared to have injured the transverse cervical artery, which had to be ligatured; unfortunately the needle was not being removed by myself, but by an assistant. In one patient a needle inserted above the clavicle appears to have touched a root of the brachial plexus, so that the patient has complained of some tingling at the point of her thumb. In the same patient the point of a needle below the clavicle momentarily pierced the lung during removal. This was owing to the fact that it had been inserted from without inwards instead of from the opposite direction, so that the point of the needle became unduly depressed during removal. No ill effects followed.

The needles in the intercostal spaces can undoubtedly be of great danger if improperly inserted. On one occasion a needle put in the fourth space caused a local pleurisy and had to be removed. I have had no other accident, but I know of two or three instances in which patients have lost their lives owing to the needles having been placed too deeply, or to their having been too long, so that pressure on their outer ends caused them to enter the mediastinum farther than was intended. In these cases the needles pierced the pericardium or the heart wall, but this should not occur if the details of technique which I have described are closely observed.

COMBINATION OF RADIUM WITH SURGERY.

Throughout this investigation I have kept before me as the ultimate object to be attained *an improvement in the final results of treatment*, and not the elimination of surgery in favour of radium simply for the sake of eliminating surgery. I have tried to avoid all bias in either direction and to remember that in the end the best results may be obtained by radium alone, by surgery

alone, or by a combination of the two. Each case has therefore been judged on its own merits, and the consequence has been a considerable degree of elasticity in the precise method used.

Obviously there are several ways in which radium may be combined with surgery, and I have not hesitated to use any of them as circumstances seemed to demand.

1. A tumour may be excised locally before any radium treatment is given, in order to remove the greater part of the growth or to establish the diagnosis. An alternative to the removal of a tumour locally before treatment is the local removal of the mammary gland. This may be necessary if the patient's psychology demands that the tumour should be got rid of completely and at once. In either case the excision should be done if possible with the diathermic needle, in order to eliminate as far as possible any dissemination of carcinoma cells. As the axilla is not being dissected, the lymphatics from the breast to the axillary glands will have to be divided, and it is certainly better to do this with the diathermic needle than with the scalpel. If the tumour is small and clearly in an early stage, this procedure seems to be justified by results. Radium treatment has been given after excision, allowing an interval of seven days or more for healing to take place. The treatment is given to the breast and lymphatic areas in exactly the same way as if the tumour were still there. Twelve patients have been treated by local excision of the tumour, of whom ten are at present without signs of disease for periods up to two years. Two have died, but in one of these the growth, as was seen in the section, had, in spite of its small size, already invaded blood-vessels, so that metastases were inevitable. In only one patient, the first treated in this way, has local recurrence taken place, but this patient was inadequately treated, as it now seems to me.

Case 52.—Age 42. Lump noticed in left breast for three months. On examination, above the areola near the edge of the mammary gland was a thickened area, 2 cm. in diameter, somewhat hard. No enlarged glands detected. Lump excised on Jan. 28, 1929. Section showed spheroidal-celled carcinoma. Radium treatment to breast and lymphatic areas. Patient has remained well since that time (2 years, 7 months).

Case 55.—Age 39. Small lump noticed in right breast for one month. On examination, small mobile lump, 2 cm. diameter, in outer part of right breast. No enlarged glands detected. Radium treatment to breast and lymphatic areas on March 7, 1929. Patient has remained without signs of disease since (2 years, 6 months).

Case 63.—Age 58. Small lump removed from left breast by Dr. Bullen, of Lincoln, on April 8, 1929. Section showed spheroidal-celled carcinoma. Radium treatment on May 13, 1929, to breast and lymphatic areas (after removal of large toxic adenoma of thyroid). Patient has remained without signs of disease since (2 years, 4 months).

Case 85.—Age 47. A small lump was removed from the inner upper quadrant of the right breast on June 1, 1929, by Mr. Joyce, of Reading. Section showed a scirrhous carcinoma. On examination the patient showed a small scar over the breast, but no signs of active disease. Prophylactic radium treatment to breast and lymphatic areas on Sept. 26, 1929. The patient has remained without signs of disease since (1 year, 11 months).

Case 90.—Age 44. Small lump removed from right breast by Dr. Nash-Wortham, of Dorchester. Proved by section to be carcinoma. No glands palpable. Prophylactic radium treatment to breast and lymphatic areas on Nov. 14, 1929. The patient has remained without signs of disease since (1 year, 10 months).

Case 117.—Age 59. Small lump in right breast excised in March, 1930, by Dr. Newman, of Bishop's Stortford. Section showed duct carcinoma. Palpable gland in axilla. Prophylactic radium treatment to breast and lymphatic areas on May 16, 1930. Patient has remained without sign of disease since (1 year, 3 months).

Case 121.—Age 45. Small lump removed from right breast by Mr. McAdam Eccles on April 1, 1930. Section showed spheroidal-celled carcinoma. Prophylactic radium treatment to breast and lymphatic areas given on June 11. Patient has remained quite well since (1 year, 3 months).

Case 133.—Age 45. Lump noticed in right breast for six months. On examination, hard lump in upper outer quadrant, 3×2 cm., not attached to skin. Diffuse mastitis in both breasts. Excision of lump on Sept. 16, 1930. Section showed spheroidal-celled carcinoma. Prophylactic radium treatment to breast and lymphatic areas on Oct. 3. Patient has remained quite well since (11 months).

Case 131.—Age 46. Small lump noticed in right breast for three weeks, which was removed locally on July 10, 1930. Section showed duct carcinoma. Prophylactic radium treatment to breast and lymphatic areas on Sept. 6. Patient has remained quite well since (1 year).

Case 93.—Age 63. Lump noticed in left breast for two months. Soft lump in upper outer quadrant excised by Dr. C. T. Neve, of Croydon, on Nov. 8, 1929. Section showed spheroidal carcinoma. Prophylactic radium treatment to breast and lymphatic areas on Dec. 5. Patient has remained without signs of disease since (1 year, 10 months).

FIG. 358.—*Case* 48. Position of radium needles.

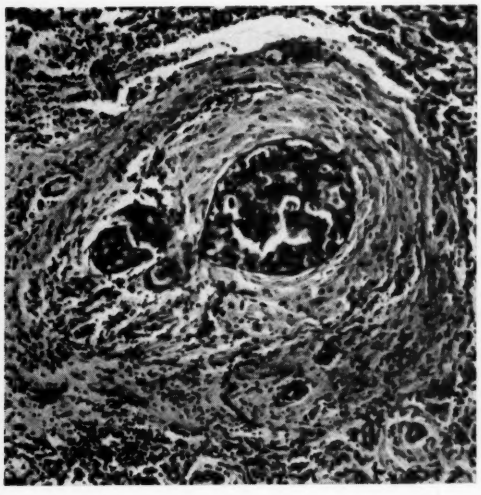

FIG. 359.—*Case* 48. Section showing invasion of blood-vessels.

Case 48.—Age 54. Small swelling noticed in right breast for one month. Enlarged gland noticed in right axilla previously. Lump and gland excised on Nov. 25, 1928. Both proved by section to be carcinoma. Section of primary growth showed invasion of blood-vessels. Insertion of radium on Dec. 28. Patient

remained well until July 16, 1929, when some enlarged glands were felt above the clavicle. Radium inserted above clavicle on Aug. 29. No trace of glands detected on Nov. 5. Patient died of spinal metastases in May, 1930. (*Figs.* 358, 359.),

2. A breast may be removed in whole or in part after treatment for more than one reason. Reference has already been made to this in describing the histological evidence of the effect of radium, and it was there mentioned that the chief reason for removal after treatment is the presence of a residual tumour and consequent uncertainty as to the complete disappearance of the growth. Another reason may be the recurrence of growth after treatment, when excision may be preferred to a second treatment with radium. In some the operation has been proved to be unnecessary, in others some active carcinoma has been found. Among 18 patients treated in this way 16 are alive up to periods of six and a half years, and 15 have no discoverable signs of disease, so that local excision after radium treatment may prove to be a valuable modification which should be practised more freely.

3. Lastly radium may be used as a form of prophylactic treatment after the performance of the radical operation. The radium can be used both in the area of operation and in the situations out of reach of operation, so that it can certainly be made a useful adjuvant in this way. The radium can be inserted at the time of the operation, as has been practised by Mr. Sampson Handley and others, or it may be used after healing has taken place. Three patients whom I have treated in this way have all remained quite well for periods up to two and a half years. I believe that if the radical operation is to continue, as it is likely to do, in frequent use, it may be advantageous to give prophylactic radium treatment whenever possible; the evidence on this point is still incomplete, though Sampson Handley has stated that an improvement in his results has followed his use of radium.

STIMULATION OF METASTASES.

It has been suggested by some critics of this method of treating carcinoma of the breast that it has stimulated dissemination of the disease, and that metastases have occurred more rapidly than if the patient had not been treated. It is obviously an exceedingly difficult thing to prove or disprove the truth of this. Certainly in the present series a number of patients have developed metastatic growths with disconcerting rapidity. I am unable to assert, however, that this was influenced by the treatment. Practically all of them were in so advanced a stage of the disease that metastases were to be expected whatever form of treatment was used. My impression is that 'follow-up' work among patients who have been operated upon provides quite as many disappointments from the same cause, and that no greater incidence can be attributed to radium. If the incidence were greater, it would presumably be shown in an inferior survival-rate, but as the survival-rate is found to be at least as good with radium (p. 479), the stimulation of metastases seems to be improbable. Theoretically also this effect appears to be unlikely, since experimental work on the effect of radium on living cells seems to show that it acts partly by inhibition of cell division and activity. It is believed also to lessen the blood-supply to the tissues treated.

CONCLUSIONS.

Experience of interstitial radium treatment of primary carcinoma of the breast in 171 cases over a period of seven years suggests that the following conclusions may be drawn :—

1. In general the results of radium treatment compare favourably with those obtained by any other form of treatment, such as pure surgery. In the most successful cases the patients are virtually normal women, and their expectation of life is at least as great as if they had been subjected to a mutilating operation.

2. No exaggerated claim is made for radium treatment, as that it should be used to supplant surgery. It is claimed, however, that radium ought to have a definite place in the treatment of carcinoma of the breast, and should often be used instead of, or combined with, surgery, according to individual circumstances.

3. The place of radium in the treatment will vary according to the stage of the disease and with other circumstances.

a. For very advanced or for inoperable tumours radium treatment is the treatment of choice. Remarkably good results can sometimes be obtained in apparently hopeless conditions.

b. For the average intermediate operable tumour the psychology of the patient or other circumstances may sometimes demand the orthodox radical operation. This may be followed by prophylactic radium treatment if desired. For unprejudiced patients the radical operation is seldom necessary, since it is justifiable in most cases to use radium alone, or radium combined with a modified operation. If primary radium treatment is not entirely successful, the patient's prospects are not impaired, and conservative surgery can usually still be applied. An exception is made in the case of very adipose patients, who are probably unsuitable for radium.

c. For the earliest and smallest tumours the radical operation is unnecessary. Excellent results can be obtained by radium alone, or by radium combined with the most conservative surgery.

4. The evidence on which these conclusions are based consists of :—

a. Preliminary microscopic examination of the tumour in the first fifty and some subsequent patients.

b. Microscopic examination of specimens removed for various reasons after radium treatment.

c. Systematic clinical examination of all patients after treatment since it was first instituted up to the present time.

d. The occurrence of normal pregnancy and lactation in one patient after radium treatment of a fully proved carcinoma of the breast without any recurrence of the disease.

5. Radium may be a very dangerous and inefficient weapon if used with insufficient care or knowledge. The present series of cases has not been without disasters, though these have been due to lack of experience in attaining the correct dosage rather than to technical faults. With proper care and knowledge interstitial radium treatment has no serious dangers.

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM.

N.S.D. = No signs of disease. N.A.D. = No active disease. B + = Microscopical section positive before treatment. A + or A − = Microscopical section positive or negative after treatment.

No.	Age	History	Type of Tumour	Microscopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
1	47	3 years	Contracting, adherent, ulcerated, Inoperable	B +	3×4 cm.	—	1.8.24 Ra. breast : 52·8 mgrm. 24 hours 4.12.24 Ra. breast : 11·5 mgrm. 120 hours 2.7.25 Local excision 18.1.27 Ra. breast : 9·0 mgrm. L. areas : 28·5 mgrm. 120 hours 10.1.30 Ra. breast : 10 mgrm. 168 hours	7 years 1 month	N.A.D.
2	59	3 years	Contracting, adherent, skin infiltrated. Inoperable	B +	3 cm.	—	29.1.25 Ra. breast : 20·5 mgrm. 168 hours 26.6.25 Local excision 6.7.26 Ra. breast : 19 mgrm. L. areas : 42 mgrm. 168 hours	4 years 3 months	Died Recurrence in breast, glands, and spine
3	43	2 years	Contracting, adherent, skin infiltrated. Inoperable	B +	5×2·5 cm.	+	5.5.25 Ra. breast : 24·5 mgrm. L. areas : 12·5 mgrm. 192 hours 12.11.27 Ra. L. areas : 15 mgrm. 144 hours	6 years 4 months	N.S.D.
4	57	5 months	Massive, adherent, skin nodules. Inoperable	B +	Whole breast	+	1.5.25 Ra. breast : 48 mgrm. L. areas : 8 mgrm. 168 hours 14.5.25 X-ray treatment 23.10.25 Local excision	7 months	Died Thoracic metastases
5	50	7 months	Massive, adherent. Inoperable	B +	Whole breast	+	11.6.25 Ra. breast : 36 mgrm. L. areas, 11 mgrm. 168 hours 23.6.25 X-ray treatment	2 months	Died Metastases in liver
6	35	1 year	Massive, fungating. Inoperable	B +	Whole breast	+	10.7.25 Ra. breast : 20 mgrm. L. areas : 10·5 mgrm. 168 hours	5 months	Died Thoracic metastases
7	57	5 years	Massive, skin involved,	B +	Whole	+	12.8.25 Ra. breast : 72 mgrm.		

7	57	5 years	Massive, skin involved, Inoperable	B +	Whole breast	+	12.8.25 Ra. breast : 72 mgrm. L. areas : 22·5 mgrm. 168 hours 12.3.26 Ra. breast : 63·5 mgrm. 144 hours	9 months	Died Thoracic metastases
8	57 (male)	1 year	Contracting, fixed, skin involved. Operable	B +	2·5 cm.	+	23.3.26 Ra. breast : 64 mgrm. L. areas : 25 mgrm. 148 hours	1 year 7 months	Died Intercurrent disease. No local recurrence
9	60	6 months	Small. Operable	B + A −	2 cm.	−	18.5.26 Lump excised Ra. breast : 42 mgrm. L. areas : 14 mgrm. 148 hours 4.4.27 Ra. breast : 20·5 mgrm. 144 hours 23.9.27 Local excision 7.12.28 Ra. L. areas, 24 mrgm. 168 hours	4 years 5 months	Died Thoracic metastases
10	63	3 years	Massive, adherent, skin infiltrated. Inoperable	B +	7·5 × 5 cm.	++	13.7.26 Ra. breast : 57·0 mgrm. L. areas : 39·5 mgrm. 148 hours 3.5.27 Ra. breast : 22·5 mgrm. 144 hours 17.1.28 Ra. breast : 33 mgrm. 120 hours 7.6.29 Ra. breast : 18 mgrm. 168 hours 9.10.30 Ra. surface application	5 years 2 months	Disease arrested
11	49	18 months	Contracting, adherent, skin infiltrated. Inoperable	B +		−	6.8.26 Ra. breast : 60·5 mgrm. L. areas : 20·0 mgrm. 130 hours	5 years 1 month	No disease locally. Spinal metastases
12	47	12 years	Contracting, ulcerated, adherent. Inoperable	B +	5 cm.	+	19.11.26 Ra. breast : 51·5 mgrm. L. areas : 37·5 mgrm. 168 hours 20.7.28 Ra. breast : 22 mgrm. 168 hours 25.10.29 Ra. gland on other side : 18 mgrm. 168 hours	4 years 6 months	Died Metastases in skin, mediastinum
13	51	11 months	Massive, skin dimpled. Metastases in mediastinum and skull. Operable	B + A +	7 × 8 cm.	+	21.12.26 Ra. breast : 45 mgrm. L. areas : 28·5 mgrm. 168 hours 29.9.27 Ra. breast : 10 mgrm. L. areas : 2 mgrm. 120 hours 19.1.28 Local excision	1 year 2 months	Died Septicæmia

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Microscopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
14	56	10 years	Massive, adherent, skin infiltrated. Inoperable	B + A +	5 × 4 cm.	—	10.2.27 Ra. breast : 32 mgrm. L. areas : 7 mgrm. 144 hours 8.6.27 Ra. breast : 36 mgrm. 144 hours 1.11.27 Local excision	4 years 2 months	Died No disease locally Spinal metastases
15	40	1 year	Adherent to skin and nipple. Operable	B +	2·5 × 3 cm.	+	17.2.27 Ra. breast : 45 mgrm. L. areas : 32·5 mgrm. 144 hours	4 years 6 months	N.S.D.
16	62	4 months	Skin attached. Operable	B +	6 cm.	+	14.4.27 Ra. breast : 51·5 mgrm. L. areas : 45 mgrm. 168 hours 12.4.28 Ra. breast : 48 mgrm. 192 hours	3 years 9 months	Died Late necrosis Mediastinal metastases
17	54	9 months	Massive, ulcerated, adherent. Inoperable	B +	8 × 5 cm.	+	20.5.27 Ra. breast : 39 mgrm. L. areas : 21 mgrm. 168 hours	9 months	Died Mediastinal metastases
18	46	2 months	Massive, adherent, skin infiltrated. Inoperable	B +	10 cm.	+	14.6.27 Ra. breast : 58·5 mgrm. L. areas : 35·5 mgrm. 168 hours 3.2.28 Ra. breast : 19 mgrm. L. areas : 16 mgrm. 192 hours	11 months	Died Spinal metastases
19	70	6 years	Contracting, skin infiltrated. Inoperable	B +	2 × 1·5 cm.	+	2.8.27 Ra. breast : 36 mgrm. L. areas : 40·5 mgrm. 168 hours	4 years 1 month	N.S.D.
20	42	18 months	Adherent, skin infiltrated. Inoperable	B +	4 cm.	+	9.8.27 Ra. breast : 27 mgrm. L. areas : 41·5 mgrm. 168 hours 31.1.28 Ra. breast : 60 mgrm. 168 hours 20.7.28 X-ray treatment	2 years 2 months	Died General metastases
21	61	3 years	Ulcerated. Operable	B + A +	2 × 3 cm.	—	20.9.27 Ra. breast : 20 mgrm. L. areas : 28·5 mgrm. 168 hours 31.1.28 Local excision 5.12.30 Excision of ulcer in axilla	3 years 11 months	N.S.D.
22	61	5 months	Attached to skin	B +	3 cm.	—	25.10.27 Ra. breast : 54·5 mgrm.	3 years	N.S.D.

							168 hours 31.1.28 Local excision 5.12.30 Excision of ulcer in axilla		
22	61	5 months	Attached to skin. Operable	B + A −	3 cm.	−	25.10.27 Ra. breast : 54·5 mgrm. L. areas : 27·0 mgrm. 168 hours 28.6.29 Ra. to breast : 41 mgrm. 168 hours 19.12.29 X-ray treatment 4.7.30 Local excision	2 y… 10 months	N.S.D.
23	44	2 years	Attached to skin. Operable	B +	3 cm.	−	25.10.27 Ra. breast : 30 mgrm. L. areas : 32·5 mgrm. 163 hours	3 years 10 months	N.S.D.
24	48	2 years	Contracting, adherent, ulcerated. Inoperable	B +	5×2·5 cm.	+	4.11.27 Ra. breast : 33 mgrm. L. areas ; 19·5 mgrm. 120 hours	3 years 10 months	N.S.D.
25	51	2 years	Adherent, skin infiltrated. Inoperable	B +	5 cm.	++	30.11.27 Ra. breast : 39 mgrm. L. areas : 38·5 mgrm. 144 hours	8 months	Died Skeletal metastases
26	39	9 months	Massive, skin attached. Operable	B +	5×4 cm.	−	16.12.27 Ra. breast : 31 mgrm. L. areas : 32 mgrm. 168 hours 12.4.28 Ra. breast : 26 mgrm. 144 hours 29.11.29 Ra. axilla : 17 mgrm. 168 hours	3 years 8 months	Pulmonary metastases
27	62	5 years	Contracting, adherent, ulcerated. Inoperable	B +	7 cm.	+	16.12.27 Ra. breast : 43 mgrm L. areas : 35·5 mgrm. 144 hours 3.10.30 Ra. breast : 24 mgrm. Axilla : 6 mgrm. 168 hours	3 years 8 months	N.S.D.
28	57	2½ years	Adherent. Inoperable	B +	4×3 cm.	++ 10×8 cm.	6.1.28 Ra. breast : 32 mgrm. L. areas : 64·5 mgrm. 168 hours	1 year	Died Disappearance of tumour. Spinal metastases
29	51	4 years	Massive, skin infiltrated with nodules. Inoperable	B +	8 cm.	+	1926, 1927 X-ray treatment 10.2.28 Ra. breast : 95 mgrm. L. areas : 35 mgrm. 168 hours	10 months	Died Skeletal metastases
30	51	1 month	Attached to nipple. Operable	B +	5 cm.	−	17.2.28 Ra. breast : 42 mgrm. L. areas : 35 mgrm. 168 hours 5.7.29 Ra. axilla : 33 mgrm. 168 hours	2 years 9 months	Died Thoracic metastases

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
31	58	15 months	Large, skin adherent. Operable	B +	6 cm.	—	30.3.28 Ra. breast : 54 mgrm. L. areas : 38 mgrm. 264 hours 4.9.28 Ra. breast : 46 mgrm. 168 hours	3 years 1 month	Died Malignant ovarian tumour
32	47	9 months	Attached to skin. Operable	B +	4 cm.	+	18.4.28 Ra. breast : 39·5 mgrm. L. areas : 30 mgrm. 216 hours 18.1.29 Ra. breast : 15 mgrm. 144 hours 7.5.29 X-ray treatment	2 years 5 months	Died Visceral metastases
33	55	7 months	Attached to skin. Operable	B +	3·5 cm.	+	20.4.28 Ra. breast : 32 mgrm. L. areas : 26 mgrm. 168 hours 1.11.29 Ra. breast : 29 mgrm. L. areas : 12 mgrm. 168 hours	1 year 11 months	Died Mediastinal metastases
34	68	2 years	Contracting, massive, adherent. Inoperable	B +	7 cm.	+	27.4.28 Ra. breast : 50 mgrm. L. areas : 26·5 mgrm. 160 hours 4.1.29 Ra. breast : 36 mgrm. 168 hours	2 years	Died No local recurrence. Spinal metastases
35	55	2 months	Massive. Operable	B +	10×7 cm.	—	27.4.28 Ra. breast : 36 mgrm. L. areas : 29 mgrm. 240 hours	11 months	Died Skeletal metastases
36	68	1 year	Contracting, ulcerated, adherent. Inoperable	B +	4×5 cm.	—	11.5.28 Ra. breast : 29 mgrm. L. areas : 27·5 mgrm. 168 hours 11.4.30 Ra. breast : 10 mgrm. 168 hours	3 years 4 months	N.A.D.
37	48	9 months	Contracting, infiltration of skin. Operable	B +	4 cm.	+	18.5.28 Ra. breast : 46 mgrm. L. areas : 30 mgrm. 168 hours 17.11.29 Ra. axilla : 21 mgrm. 168 hours	2 years	Died Metastases in jaw and spine
38	77	1 year	Massive, skin attached.	B +	7 cm.	—	1.6.28 Ra. breast : 47 mgrm.	3 years	N.S.D.

						17.11.29	Ra. axilla : 21 mgrm. 168 hours		
38	77	1 year	Massive, skin attached. Operable	B + A −	7 cm.	−	1.6.28 Ra. breast : 47 mgrm. L. areas : 27 mgrm. 168 hours 7.12.28 Excision of residual lump	3 years 8 months	N.S.D.
39	52	1 year	Massive, adherent. Inoperable	B +	10 cm.	−	8.6.28 Ra. breast : 63 mgrm. L. areas : 28 mgrm. 240 hours 9.4.29 Ra. breast : 39 mgrm. 120 hours	1 year 6 months	Died Mediastinal metastases
40	57	2 months	Adherent. Inoperable	B +	6 × 3·5 cm.	−	8.6.28 Ra. breast : 40 mgrm. L. areas : 28 mgrm. 168 hours	3 years 3 months	N.S.D.
41	68	2 years	Massive, fungating, Inoperable	B + A +	6 cm.	+	22.6.28 Ra. breast : 42 mgrm. L. areas : 28·5 mgrm. 168 hours 8.3.29 Excision of residual lump	9 months	Died Intercurrent disease
42	58	2 years 6 months	Contracting, adherent. Operable	B + A +	6 cm.	+	22.6.28 Ra. breast : 43 mgrm. L. areas : 26 mgrm. 168 hours 1.8.29 Ra. Pect. musc. : 24 mgrm. 168 hours 21.11.29 Local excision : breast	3 years 2 months	N.S.D.
43	63	3 years	Ulcerated. Operable	B +	5 cm.	−	6.7.28 Ra. breast : 42 mgrm. L. areas : 24 mgrm. 168 hours	2 years 5 months	Died Pulmonary metastases
44	69	1 year	Massive, ulcerated. Operable	B +	5 × 8 cm.	+	18.7.28 Ra. breast : 60 mgrm. L. areas : 34 mgrm. 144 hours	7 months	Died Pulmonary metastases
45	40	2 years	Contracting, ulcerated, adherent. Operable	B +	5 × 6 cm.	+	23.8.28 Ra. breast : 50·5 mgrm. L. areas : 26 mgrm. 264 hours 15.2.29 Ra. breast : 52 mgrm. L. areas : 6 mgrm. 168 hours 29.8.29 X-ray treatment	1 year 8 months	Died Thoracic and spinal metastases
46	59	2 months	Attached to skin. Operable	B +	5 × 6 cm.	−	14.9.28 Ra. Lt. breast : 43 mgrm. L. areas : 23 mgrm. 168 hours 10.5.29 Ra. axilla : 30 mgrm. 168 hours 24.4.31 Removal, Rt. breast and insertion of 66 mgrm. Ra. 168 hours	3 years	N.S.D.

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
47	68	9 months	Contracting, ulcerated, adherent. Inoperable	B +	6·5 × 5 cm.	−	23.11.28 Ra. breast : 36 mgrm. L. areas : 20 mgrm. 144 hours 6.12.29 X-ray treatment	2 years 2 months	Died Thoracic metastases
48	54	3 months	Small. Operable. Microscopic invasion of blood-vessels	B +	2 cm.	+	25.11.28 Lump and glands excised 28.12.28 Ra. breast : 27 mgrm. L. areas : 37·5 mgrm. 168 hours 29.8.29 Ra. L. areas : 10 mgrm. 168 hours	1 year 6 months	Died Spinal metastases
49	61	1 year	Attached to skin. Operable		4·5 cm.	+	4.1.29 Ra. breast : 51 mgrm. L. areas : 34 mgrm. 168 hours 10.10.29 Ra. breast : 29 mgrm. L. areas : 7 mgrm. 168 hours	1 year 4 months	Died Mediastinal metastases
50	39	1 year	Attached to skin. Operable		5 × 4 cm.	−	5.2.29 Ra. breast : 33 mgrm. L. areas : 30 mgrm. 90 hours 5.8.29 Ra. breast : 46 mgrm. 168 hours	1 year 2 months	Died Mediastinal metastases
51	43	2 months	Attached to nipple. Operable	A +	3 cm.	+	9.2.29 Ra. breast : 30 mgrm. L. areas : 30 mgrm. 168 hours 19.9.30 Ra. breast : 85 mgrm. 168 hours 19.6.31 Removal of breast, and deep X-ray treatment	2 years 7 months	Disease arrested
52	42	3 months	Early. Operable	B +	2 cm.	−	28.1.29 Lump excised 13.2.29 Ra. breast : 27 mgrm. L. areas : 21 mgrm. 120 hours	2 years 7 months	N.S.D.
53	46	1 year	Attached to skin. Operable	A +	4 cm.	+	20.2.29 Ra. breast : 48 mgrm. L. areas : 26 mgrm. 144 hours 24.9.29 Local removal of breast 24.10.29 X-ray treatment	1 year 4 months	Died Thoracic metastases

							144 hours 24.9.29 Local removal of breast 24.10.29 X-ray treatment		
54	57	4 months	Attached to nipple. Operable	A +	5×3 cm.	+	1.3.29 Ra. breast : 36 mgrm. L. areas : 26 mgrm. 168 hours 10.7.30 Local removal of breast	2 years 6 months	N.S.D.
55	39	1 month	Early. Operable	B +	2 cm.	—	27.2.29 Excision of lump 7.3.29 Ra. breast : 30 mgrm. L. areas : 26 mgrm. 144 hours	2 years 6 months	N.S.D.
56	41	7 months	Massive, adherent, skin infiltrated. Inoperable		Whole breast	++	8.3.29 Ra. breast : 48 mgrm. L. areas : 42 mgrm. 144 hours	3 months	Died of the disease
57	65	Local removal of breast, 31.12.28		B +		—	13.3.29 Ra. 41 mgrm. 168 hours	2 years 6 months	N.S.D.
58	47	8 months	Adherent. Operable	A +	6×2.5 cm.	+	21.3.29 Ra. breast : 28 mgrm. L. areas : 26 mgrm. 168 hours 7.2.30 Excision of residual lump 16.1.31 Ra. nodule : 12 mgrm. 168 hours	2 years 5 months	Metastases in femur
59	63	2 weeks	Early, skin attached. Operable		2·5 cm.	—	9.4.29 Ra. breast : 30 mgrm. L. areas : 26 mgrm. 138 hours	2 years 5 months	N.S.D.
60	71	1 year	Contracting, adherent. Operable		2·5 cm.	—	19.4.29 Ra. breast : 25 mgrm. L. areas : 28·5 mgrm. 120 hours	2 years 4 months	N.A.D.
61	49	3 months	Not adherent. Operable		5 cm.	—	3.5.29 Ra. breast : 47 mgrm. L. areas : 20 mgrm. 168 hours	2 years 4 months	N.S.D.
62	58	6 months	Skin attached. Operable		2·5 cm.	+	3.5.29 Ra. breast : 36 mgrm. L. areas : 18·5 mgrm. 168 hours	2 years 4 months	N.S.D.
63	58	Lump excised from breast, 8.4.29		B +		—	13.5.29 Ra. breast : 27 mgrm. L. areas : 26 mgrm. 136 hours	2 years 4 months	N.S.D.
64	58	1 year	Contracting, skin infiltrated. Operable	A +	5 cm.	—	16.5.29 Ra. breast : 36 mgrm. L. areas : 21 mgrm. 168 hours 3.7.31 Removal of breast and axillary glands	2 years 3 months	Disease arrested

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Microscopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
65	33	5 weeks	Small. Operable		2·5 cm.	+	31.5.29 Ra. breast : 27 mgrm. L. areas : 32 mgrm. 168 hours 23.9.30 Ra. breast : 28 mgrm. Axilla : 6 mgrm. 168 hours	2 years 1 month	Died Thoracic metastases. Carcinoma of uterus
66	57	2 weeks	Early. Operable		1·5 cm.	—	8.6.29 Ra. breast : 20 mgrm. L. areas : 26 mgrm. 168 hours	2 years 3 months	N.S.D.
67	47	6 months	Adherent, ulcerated. Inoperable		5 cm.	—	11.6.29 Ra. breast : 25 mgrm. L. areas : 32 mgrm. 168 hours	5 months	Died Spinal metastases
68	52	1 year	Not adherent. Operable		6 cm.	+	12.6.29 Ra. breast : 24 mgrm. L. areas : 21 mgrm. 168 hours	2 years 3 months	N.S.D.
69	71	3½ years	Contracting, skin infiltrated. Operable	A Br.— Gl.+	4 cm.	+	14.6.29 Ra. breast : 35 mgrm. L. areas : 26 mgrm. 168 hours 17.10.30 Local removal of breast. L. Ax. glands	2 years 3 months	N.A.D.
70	60	6 weeks	Skin attached. Operable		6 cm.	—	18.6.29 Ra. breast : 42 mgrm. L. areas : 30 mgrm. 168 hours 12.12.29 Ra. L. areas : 15 mgrm. 168 hours 4.9.30 Ra. Surface application	1 year 5 months	Died Visceral metastases
71	67	6 weeks	Not adherent. Operable		5 cm.	+	21.6.29 Ra. breast : 31 mgrm. L. areas : 31 mgrm. 168 hours 2.9.30 Ra. breast : 27 mgrm. L. areas : 40 mgrm. 168 hours	2 years 2 months	N.S.D.
72	62	9 months	Massive, fungating. Inoperable		12·5 cm.	+	26.6.29 Ra. breast : 32·1 mgrm. L. areas : 30·1 mgrm. 168 hours	2 months	Died Visceral metastases
73	44	2–3 years	Skin attached.		5 cm.	—	26.6.29 Ra. breast : 26 mgrm.	2 years	N.S.D.

							168 hours			stases
73	44	2–3 years	Skin attached. Operable		5 cm.	—	26.6.29	Ra. breast : 26 mgrm. L. areas : 19·7 mgrm. 168 hours	2 years 2 months	N.S.D.
74	55	Removal	of breast with axillary glands, 23.10.29	B +		+	8.7.29	Ra. L. areas : 32 mgrm. 168 hours	2 years 2 months	N.S.D.
75	60	3 weeks	Skin adherent. Operable	A +	4 cm.	+	11.7.29 23.4.30 19.6.30 25.4.31	Ra. breast : 39 mgrm. L. areas : 24 mgrm. 168 hours Local removal of breast Ra. to scar : 40 mgrm. 144 hours Surface application Ra. to scar	2 years 2 months	No local recurrence. Thoracic metastases
76	50		Adherent. Operable	A —	8 cm.	—	19.7.29 9.1.30 25.11.30	Ra. breast : 53 mgrm. L. areas : 31 mgrm. 168 hours Ra. breast : 14 mgrm. 168 hours Local removal of breast	2 years 1 month	N.S.D.
77	66	Removal	of breast with axillary glands, 7.6.29	B +		+	21.8.29	Ra. L. areas : 35 mgrm. 144 hours	2 years	N.S.D.
78	46	6 weeks	Cystic, skin not adherent. Operable	A +	4×5 cm.	—	18.1.29 24.9.29 10.4.31	Ra. breast : 24 mgrm. L. areas : 23 mgrm. 168 hours Excision of cyst Local removal of breast	2 years 7 months	N.S.D.
79	55	6 months	Skin adherent. Operable	A +	6 cm.	—	28.8.29 1.5.30 9.30	Ra. breast : 42 mgrm. L. areas : 26 mgrm. 168 hours Local removal of breast Ra. surface application	2 years	Mediastinal metastases. Skin nodules
80	58	8 months	Massive, adherent, skin infiltrated. Inoperable		Whole breast	+	3.9.29 12.29	Ra. breast : 38·5 mgrm. L. areas : 22·5 mgrm. 168 hours X-ray treatment	8 months	Died Visceral metastases
81	62	1 year	Nipple attached, skin infiltrated. Operable		10 cm.	+	4.9.29	Ra. breast : 58 mgrm. L. areas : 28 mgrm. 168 hours	8 months	Died Metastases in skin and skeleton
82	42	3 weeks	Nipple adherent Operable	A —	7 cm.	—	10.9.29 30.10.30	Ra. breast : 46 mgrm. L. areas : 24·5 mgrm. 168 hours Local removal of breast	2 years	N.S.D.

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
83	58	2 years	Small. Operable		2·5 cm.	+	11.9.29 Ra. breast : 21 mgrm. L. areas : 20 mgrm. 168 hours	2 years	N.S.D.
84	86		Skin attached. Operable		4 × 3 cm.	+	18.9.29 Ra. breast : 30 mgrm. L. areas : 26 mgrm. 168 hours	1 year 11 months	No local disease. Visceral metastases
85	47	1.6.29,	lump removed from breast	B +		−	26.9.29 Ra. breast : 24 mgrm. L. areas : 26 mgrm. 168 hours	1 year 11 months	N.S.D.
86	43	10 months	Skin attached. Operable		4 cm.	+	2.10.29 Ra. breast : 38 mgrm. L. areas : 28 mgrm. 192 hours	1 year 2 months	Died Spinal metastases
87	49	3 months	Contracting. Operable		5 × 4 cm.	+	3.10.29 Ra. breast : 27 mgrm. L. areas : 33·5 mgrm. 168 hours 1.5.31 Ra. breast : 10 mgrm. L. areas : 14 mgrm. 168 hours	1 year 10 months	Disease arrested
88	63	2 years 8 months	Massive. Operable		10 cm.	+	28.10.29 Ra. breast : 57 mgrm. L. areas : 32 mgrm. 168 hours 13.11.30 Ra. breast : 50 mgrm. 168 hours	1 year 8 months	Died Visceral metastases. Local improvement
89	37	6 months	Small, not adherent. Operable		2 × 1·5 cm.	−	1.3.29 Ra. breast : 21 mgrm. L. areas : 29 mgrm. 144 hours	2 years 6 months	N.S.D.
90	44	June, 1929,	lump excised from breast	B +		−	14.11.29 Ra. breast : 36 mgrm. L. areas : 29 mgrm. 168 hours	1 year 10 months	N.S.D.
91	65	5 months	Not adherent. Operable		4 × 5 cm.	+	21.11.29 Ra. breast : 40 mgrm. L. areas : 38 mgrm. 168 hours	3 months	Died Intercurrent disease
92	56	2 years	Ulcerated. Inoperable		6 cm.	−	29.11.29 Ra. breast : 48 mgrm. L. areas : 19 mgrm. 168 hours	1 year	Died Visceral metastases

92	56	2 years	Ulcerated. Inoperable		6 cm.	—	29.11.29	Ra. breast : 48 mgrm. L. areas : 19 mgrm. 168 hours	1 year	Died Visceral metastases
93	63	2 months	Early, skin attached. Operable	B +	2 cm.	+	8.11.29 5.12.29	Lump excised Ra. breast : 34 mgrm. L. areas : 35 mgrm. 168 hours	1 year 10 months	N.S.D.
94	35	4 months	Skin attached. Operable	A Br. — Gl. +	5 cm.	—	12.12.29 12.1.31	Ra. breast : 53 mgrm. L. areas : 30 mgrm. 160 hours Local excision of the residual lump with gland	1 year 9 months	N.S.D.
95	75	4 years	Contracting, adherent. Inoperable		5 cm.	—	13.12.29	Ra. breast : 54 mgrm. L. areas : 26 mgrm. 144 hours	1 year 9 months	N.S.D.
96	64	2 years	Massive, skin attached. Operable		6 × 7 cm.	+	20.12.29	Ra. breast : 56 mgrm. L. areas : 23 mgrm. 168 hours	1 year	Died Spinal metastases
97	57	1 month	Skin attached. Operable		4 cm.	—	30.12.29	Ra. breast : 50 mgrm. L. areas : 23 mgrm. 168 hours	1 year 8 months	Metastases in C.N.S.
98	73	2 weeks	Early, nipple attached. Operable		4 cm.	—	9.4.30	Ra. breast : 42 mgrm. L. areas : 24 mgrm. 190 hours	1 year 5 months	N.A.D.
99	48	Several months	Skin attached. Operable		4 × 2 cm.	—	23.1.30	Ra. breast : 25 mgrm. L. areas : 32 mgrm. 168 hours	1 year 7 months	N.S.D.
100	57	9 months	Small, attached to skin. Operable		2·5 cm.	+	24.1.30	Ra. breast : 38 mgrm. L. areas : 32 mgrm. 168 hours	1 year 7 months	N.S.D.
101	50	3 months	Skin infiltrated, nipple attached. Inoperable		5 cm.	—	14.2.30	Ra. breast : 47 mgrm. L. areas : 29 mgrm. 168 hours	1 year 7 months	No disease locally. Abdominal metastases
102	66	3 months	Small. Operable		3 cm.	—	20.2.30	Ra. breast : 31 mgrm. L. areas : 29 mgrm. 168 hours	7 months	Died Metastases in liver
103	41	1 year	Massive, nipple attached, secondary growth in the eye. Operable		Whole breast	+	21.2.30	Ra. breast : 74 mgrm. L. areas : 32 mgrm. 168 hours	4 months	Died General metastases

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
104	55	5 years	Massive, ulcerated, adherent. Inoperable	A +	13 cm.	+	27.2.30 Ra. breast : 54 mgrm. L. areas : 21 mgrm. 168 hours 27.8.30 Ra. breast : 32 mgrm. 168 hours 2.7.31 Excision of residual mass	1 year 6 months	N.S.D.
105	56	1 week	Small, skin attached. Operable		2 cm.	+	1.3.30 Ra. breast : 24 mgrm. L. areas : 20 mgrm. 168 hours	1 year 6 months	N.S.D.
106	49	7 months	Massive, skin attached. Operable	A +	7×3 cm.	−	7.3.30 Ra. breast : 51 mgrm. L. areas : 25 mgrm. 168 hours 29.11.30 Local removal of breast	1 year 6 months	N.S.D.
107	53	3 weeks	Skin attached. Operable	A +	5 cm.	−	6.3.30 Ra. breast : 47 mgrm. L. areas : 30 mgrm. 168 hours 16.10.30 Ra. breast : 71 mgrm. 168 hours 2.7.31 Excision of residual nodule	1 year 6 months	N.S.D.
108	59	7 months	Massive, nipple attached. Operable		6 cm.	−	21.3.30 Ra. breast : 24 mgrm. L. areas : 29 mgrm. 168 hours	7 months	Died Metastases in liver
109	72	6 years	Contracting, skin infiltrated. Operable		4 cm.	−	1.4.30 Ra. breast : 42 mgrm. L. areas : 24 mgrm. 168 hours 17.3.31 Ra. recurrent nodule in skin, 13 mgrm. 168 hours	1 year 5 months	N.A.D.
110	65	1 week	Skin attached. Inoperable		4 cm.	++	8.4.30 Ra. breast : 39 mgrm. L. areas : 20 mgrm. 168 hours	1 year	Died Skeletal metastases
111	50	1 month	Massive, not adherent. Operable	A +	7×5 cm.	+	11.4.30 Ra. breast : 49 mgrm. L. areas : 20 mgrm. 192 hours 6.2.31 Local removal of breast	1 year 5 months	N.S.D.
112	57	1 year	Skin attached, nipple		5×7 cm.	−	10.4.30 Ra. breast : 42 mgrm.	1 year	No local disease.

							192 hours 6.2.31 Local removal of breast		
112	57	1 year	Skin attached, nipple retracted. Operable		5×7 cm.	—	10.4.30 Ra. breast : 42 mgrm. L. areas : 22 mgrm. 168 hours 23.10.30 Ra. breast : 70 mgrm. 168 hours	1 year 5 months	No local disease. Mass in abdomen and (?) metastases Rt. femur
113	40	4 months	Nipple retracted. Operable		5×4 cm.	—	20.3.30 Ra. breast : 27 mgrm. L. areas : 21 mgrm. 168 hours	1 year 5 months	N.S.D.
114	57	3 months	Not adherent. Operable	B +	Diffuse mass	—	27.3.30 Local removal of breast Ra. L. areas : 36 mgrm. 168 hours	1 year 5 months	N.S.D.
115	54	6 months	Massive, skin attached. Inoperable		8×10 cm.	+	8.5.30 Ra. breast : 68 mgrm. L. areas : 18 mgrm. 168 hours 18.9.30 Ra. breast : 54 mgrm. L. areas : 18 mgrm. 168 hours	9 months	Died Mediastinal metastases
116	66	8 months	Adherent to skin and deep fascia, nipple retracted. Operable	A +	5 cm.	—	9.5.30 Ra. breast : 30 mgrm. L. areas : 32 mgrm. 168 hours 27.4.31 Local removal of breast	1 year 4 months	N.S.D.
117	59	March, 1930, small lump excised from breast		B +		+	16.5.30 Ra. breast : 24 mgrm. L. areas : 23 mgrm. 168 hours	1 year 3 months	N.S.D.
118	35	2 weeks	Massive. Inoperable		10 cm.	+	17.4.30 Ra. breast : 63 mgrm. L. areas : 30 mgrm. 168 hours 18.9.30 Ra. breast : 33 mgrm. L. areas : 6 mgrm. 168 hours 20.11.30 Ra. to other breast : 47 mgrm. 168 hours	1 year 1 month	Died Visceral metastases
119	52	2 years	Skin attached. Operable		3 cm.	—	5.6.30 Ra. breast : 33 mgrm. L. areas : 20 mgrm. 168 hours	1 year 3 months	Disease arrested
120	53	5 months	Craggy mass, skin attached. Operable	A +	6×4 cm.	+	10.6.30 Ra. breast : 46 mgrm. L. areas : 28 mgrm. 168 hours 9.1.31 Local removal of breast	1 year 3 months	N.S.D.
121	45	March, 1930, lump removed from breast		B +		—	11.6.30 Ra. breast : 38 mgrm. L. areas : 23 mgrm. 168 hours	1 year 3 months	N.S.D.

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
122	57	3 months	Skin attached. Operable		6×4 in.	+	15.5.30 Ra. breast : 33 mgrm. L. areas : 26 mgrm. 168 hours	1 year 1 month	Died Thoracic and spinal metastases
123	61	1 year	Massive, skin infiltrated. Inoperable		6 cm.	+	19.6.30 Ra. breast : 59 mgrm. L. areas : 25 mgrm. 168 hours 26.3.31 Ra. breast : 39 mgrm. Axilla : 24 mgrm. 168 hours	1 year 2 months	N.S.D.
124	64	2 weeks	Adherent to skin and fascia, nipple retracted. Operable	A +	4×3·5 cm.	−	20.6.30 Ra. breast : 32 mgrm. L. areas : 32 mgrm. 168 hours 20.2.31 Excision of residual lump	1 year 2 months	N.S.D.
125	46	6 months	Massive, skin infiltrated. Operable		9×7 cm.	−	26.6.30 Ra. breast : 58 mgrm. L. areas : 26 mgrm. 168 hours	1 year 2 months	N.S.D.
126	57	1 year	Ulcerated, adherent. Inoperable		5×4 cm.	−	11.7.30 Ra. breast : 30 mgrm. L. areas : 26 mgrm. 168 hours	1 year 2 months	Disease arrested
127	52	3 months	Not adherent. Operable		4 cm.	+	17.7.30 Ra. breast : 46 mgrm. L. areas : 20 mgrm. 168 hours	1 year 1 month	N.S.D.
128	73	18 months	Ulcerated, skin infiltrated, not adherent. Operable	A +	7 cm.	−	17.7.30 Ra. breast : 34 mgrm. L. areas : 29 mgrm. 168 hours 11.8.30 Ra. breast : 30 mgrm. 168 hours 8.1.31 Excision of residual lump	1 year 1 month	N.S.D.
129	52	3 months	Not attached. Operable		5 cm.	+	26.8.30 Ra. breast : 40 mgrm. L. areas : 27 mgrm. 168 hours	6 months	Died Visceral metastases
130	61	15 months	Not adherent. Operable		3 cm.	+	28.8.30 Ra. breast : 21 mgrm. L. areas : 29 mgrm. 168 hours	1 year	N.S.D.
131	46	3 weeks	10.7.30, Small lump	B +		−	6.9.30 Ra. breast : 30 mgrm.	1 year	N.S.D.

			Operable				L. areas : 29 mgrm. 168 hours			
131	46	3 weeks	10.7.30, Small lump excised from breast	B +		—	6.9.30 Ra. breast : 30 mgrm. L. areas : 29 mgrm. 216 hours	1 year	N.S.D.
132	75	1 year	Massive, ulcerated, skin infiltrated widely. Inoperable		7 cm.	+	17.9.30 Ra. breast : 58 mgrm. L. areas : 31 mgrm. 240 hours	11 months	N.S.D.
133	45	6 months	16.9.30, Excision of lump from breast	B +		—	3.10.30 Ra. breast : 43 mgrm. L. areas : 23 mgrm. 168 hours	11 months	N.S.D.
134	64	5 years	Contracting, adherent. Inoperable.		3 cm.	+	9.10.30 Ra. breast : 58 mgrm. L. areas : 21 mgrm. 168 hours	11 months	N.S.D.
135	49	2 months	Skin adherent. Operable		1·5 cm.	—	9.10.30 Ra. breast : 46 mgrm. L. areas : 26 mgrm. 168 hours	11 months	N.S.D.
136	45	18 months	Skin adherent, deviation of nipple. Operable		4 cm.	—	14.10.30 Ra. breast : 54 mgrm. L. areas : 32 mgrm. 168 hours	11 months	N.S.D.
137	41	4 months	Small, not adherent, Operable		3 cm.	+	24.10.30 Ra. breast : 45 mgrm. L. areas : 16 mgrm. 168 hours	10 months	N.S.D.
138	36	1 week	Skin adherent, nipple retracted. Operable		4 cm.	—	30.10.30 Ra. breast : 36 mgrm. L. areas : 29 mgrm. 168 hours	10 months	N.S.D.
139	58	About 4 months	Nipple retracted and adherent. Operable		3×2 cm.	—	31.10.30 Ra. breast : 46 mgrm. L. areas : 30 mgrm. 168 hours	10 months	N.S.D.
140	47	August,	1930, lump excised from breast	B +		+	31.10.30 Ra. breast : 45 mgrm. L. areas : 30 mgrm. 168 hours	7 months	Died Mediastinal metastases
141	64	4 months	Not attached. Operable	A —	3 cm.	—	28.11.30 Ra. breast : 52 mgrm. L. areas : 36 mgrm. 168 hours 10.4.31 Excision of residual lump	9 months	N.S.D.
142	60	1 year	Skin dimpled, nipple retracted. Operable		3 cm.	+	28.11.30 Ra. breast : 35 mgrm. L. areas : 29 mgrm. 155 hours	9 months	N.S.D.

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
143	72	2 years	Massive, fixed, skin infiltrated. Inoperable		10 × 9 cm.	+	27.11.30 Ra. breast : 48 mgrm. L. areas : 33 mgrm. 168 hours 25.6.31 Ra. residual nodule : 20 mgrm. 168 hours	9 months	N.S.D.
144	62	21.11.30, local removal of Rt. nipple and areola Lt. breast, small, attached to nipple. Operable	B +	3 cm.	−	3.12.30 Ra. Lt. breast : 46 mgrm L. areas : 24 mgrm. 168 hours 10.12.30 Ra. Rt. breast : 44 mgrm. L. areas : 24 mgrm. 168 hours		9 months	N.S.D.
145	68	9 weeks	Skin dimpled. Operable		3 cm.	−	4.12.30 Ra. breast : 55 mgrm. L. areas : 29 mgrm. 168 hours	9 months	Improving
146	69	5 months	Small, skin dimpled. Operable		3 cm.	−	5.12.30 Ra. breast : 36 mgrm. L. areas : 20 mgrm. 159 hours	9 months	N.S.D.
147	53	1 year	Not adherent. Operable	A −	3 cm.	−	12.12.30 Ra. breast : 56 mgrm. L. areas : 21 mgrm. 216 hours 14.8.31 Excision of residual lump	9 months	N.S.D.
148	60	6½ years	Not attached. Operable		3 cm.	−	8.1.31 Ra. breast : 43 mgrm. L. areas : 26 mgrm. 168 hours	8 months	N.S.D.
149	64	2 years	Massive, fungating, ulcerated. Inoperable		8 cm.	−	19.1.31 Ra. Lt. breast : 52 mgrm. L. areas : 24 mgrm. 168 hours 16.6.31 Ra. Lt. breast : 31 mgrm. Rt. breast : 44 mgrm. 168 hours	7 months	Healing Retroclavicular extension
150	67	2 months	Small, not attached. Operable		3 cm.	+	26.1.31 Ra. breast : 40 mgrm. L. areas : 22 mgrm. 168 hours	7 months	N.S.D.
151	67	3 years	Contracting, skin attached. Operable		3 cm.	+	6.2.31 Ra. breast : 43 mgrm. L. areas : 32 mgrm. 168 hours	7 months	N.S.D.
152	39	9 months	Small, skin attached. Operable		2·5 cm.	+	12.2.31 Ra. breast : 45 mgrm. L. areas : 23 mgrm.	7 months	Improving

			tached. Operable					L. areas : 32 mgrm. 168 hours		
152	39	9 months	Small, skin attached. Operable		2·5 cm.	+	12.2.31	Ra. breast : 45 mgrm. L. areas : 22 mgrm. 168 hours	7 months	Improving
153	46	2 months	Not adherent. Operable		4 cm.	—	16.2.31	Ra. breast : 44 mgrm. L. areas : 30 mgrm. 168 hours	6 months	N.S.D.
154	55	6 years	Massive, skin infiltrated. Inoperable	B +	7 cm.	+	27.2.31	Ra. breast : 57 mgrm. L. areas : 26 mgrm. 168 hours	6 months	N.S.D.
155	54	1 month	Not adherent. Operable	B +	indefinite	—	23.1.31 6.3.31	Local removal of breast Ra. breast : 48 mgrm. L. areas : 28 mgrm. 168 hours	8 months	N.S.D.
156	44	2 months	Skin adherent, nipple retracted. Operable		4 cm.	+	9.3.31	Ra. breast : 57 mgrm. L. areas : 30 mgrm. 168 hours	6 months	N.S.D.
157	70	3 months	Contracting, skin adherent. Operable		4 cm.	+	2.4.31	Ra. breast : 39 mgrm. L. areas : 33 mgrm. 168 hours	5 months	Improving
158	62	8 months	Massive, skin adherent. Operable		7 cm.	—	2.4.31	Ra. breast : 70 mgrm. L. areas : 26 mgrm. 168 hours	5 months	Improving
159	59	5 months	Small, skin dimpled. Operable	B +	3 cm.	—	18.2.31 9.4.31	Local removal of lump Ra. breast : 48 mgrm. L. areas : 30 mgrm. 168 hours	5 months	N.S.D.
160	56	7 months	Small, skin adherent. Operable	B +	3 cm.	—	17.4.31	Local removal of lump and insertion of Ra. Ra. breast : 30 mgrm. L. areas : 42 mgrm. 168 hours	4 months	N.S.D.
161	61	18 months	Contracting, skin attached. Operable	B +	2·5 cm.	—	30.3.31 27.4.31	Local removal of breast Ra. breast : 21 mgrm. L. areas : 23 mgrm. 168 hours	5 months	N.S.D.
162	69	1 year	Massive. Inoperable		7 cm.	+	26.5.31	Ra. breast : 53 mgrm. L. areas : 36 mgrm. 168 hours	3 months	Improving
163	56	3 months	Massive, adherent, skin infiltrated. Inoperable		8 cm.	++	29.5.31	Ra. breast : 80 mgrm. L. areas : 22 mgrm. 168 hours	3 months	N.S.D.

ANALYSIS OF 171 CASES OF CANCER OF BREAST TREATED BY RADIUM—*continued.*

No.	Age	History	Type of Tumour	Micro-scopical Section	Size of Tumour	Glands	Treatment	Time	Result to 15.9.31
164	63	3 months	Massive, not adherent. Operable		7 cm.	—	13.11.30 Ra. breast : 35 mgrm. L. areas : 29 mgrm. 168 hours	10 months	N.S.D.
165	50	1 month	Not adherent. Operable	B +	5×3 cm.	—	8.5.31 Local removal of breast 19.6.31 Ra. breast : 21 mgrm. L. areas : 31 mgrm. 168 hours	4 months	N.S.D.
166	56	5 months	Massive, skin attached. Operable	B +	6 cm.	+	29.5.31 Local removal of breast 26.6.31 Ra. breast : 24 mgrm. L. areas : 20 mgrm. 168 hours	3 months	N.S.D.
167	45	1 month	Skin dimpled. Operable	B +	3 cm.	—	8.6.31 Local removal of breast 2.7.31 Ra. breast : 12 mgrm. L. areas : 32 mgrm. 168 hours	3 months	N.S.D.
168	42	18 months	Massive, adherent, skin infiltrated. Inoperable		8×9 cm.	++	9.7.31 Ra. breast : 42 mgrm. L. areas : 41 mgrm. 168 hours	2 months	Improving
169	47	1 year	Contracting, adherent. Operable		4 cm.	—	9.7.31 Ra. breast : 63 mgrm. L. areas : 38 mgrm. 168 hours	2 months	Improving
170	41	6 weeks	Soft mobile lump. Operable	B +	3×2 cm.	—	23.6.31 Local removal of lump 10.7.31 Ra. breast : 24 mgrm. L. areas : 28 mgrm. 168 hours	2 months	N.S.D.
171	60	2 years	Skin adherent, nipple retracted. Operable		5×2·5 cm.	+	18.7.31 Ra. breast : 30 mgrm. L. areas : 27 mgrm. 168 hours	2 months	Improving

NOTES ON THE STATISTICAL ANALYSIS OF THE CASES.*

By Dr. Janet E. Forber (*née* Lane-Claypon).

The most important group of cases is that in which the treatment was begun three or more years ago. There are 46 of these. In order to enable an ultimate comparison to be made with results obtained at three years by surgery alone, these 46 cases have been divided into three classes :—

Class I. Operable ; no glands palpable.

Class II. Operable ; glands palpable.

Class III. Inoperable.

As a matter of interest, results obtained with patients treated over two and under three years ago, and also over one year and under two years ago, have been taken out and are shown in the table below.

	Total Cases	Alive at 3 Years	Died of Cancer	Died of Intercurrent Disease	Percentage Alive at 3 Years
		Patients treated three or more years ago.			
Class I ..	9	7	2	0	77·7
Class II ..	11	4	5	2	36·3
Class III ..	26	12	13	1	46·1
		Patients treated over two and under three years ago.			
Class I ..	16	13	3	0	81·25
Class II ..	16	11	5	0	68·75
Class III ..	5	0	5	0	0·0
		Patients treated over one year and under two years ago.			
Class I ..	22	20	2	0	90·9
Class II ..	16	10	5	1	62·5
Class III ..	10	5	5	0	50·0

Note.—Of those patients at three years, 3 in Class I, 1 in Class II, and 4 in Class III had either died of cancer or were dying at the time of writing. One of these in Class I died of a malignant ovarian tumour. Accepting the results published by the Ministry of Health (loc. cit., p. 33) the percentage of those treated by surgery alone and alive at three years in Class I was between 75 and 78, and in Class II between 41 and 44.

Attention should be drawn to the fact that the classification of the operable cases is necessarily based on the palpation of the glands and not on the findings at the time of operation, or after microscopical examination. This renders it almost certain that some of the cases appearing in Class I had glands which were already invaded by growth, while Class II includes some very advanced, but still operable, cases. In comparing the results with those obtained by operation alone these sources of divergence are probably of considerable importance. Further, two cases, with no palpable glands but with ulceration of the skin, have been placed in Class II, since, with

* Dr. J. E. Forber has very kindly compiled these notes from the proofs of the detailed table on pp. 460–478.

operation alone, these give very bad results, in no way comparable with Class I cases. (For an estimate of the errors cp. Chapters 6 and 7, *Ministry of Health Reports on Public Health and Medical Subjects*, No. 51.)

Two cases (one over three years since treatment and one over one year), both locally operable but having remote metastases at the time of treatment, have been classed among the inoperable ones, since it is unlikely that they would in fact have been operated upon had this been the only method of treatment available. Both have died.

The present sample is small, and does not enable any reliable data to be taken out to show the differences in results which there may be in the various methods of treatment, i.e., by radiology alone, or combined with surgery. A number of patients who died showed no local recurrence of the disease, but these have not been shown separately in the table.

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ON THE EFFECT OF ANÆMIA ON THE REACTIONS OF THE SKIN AND OF TUMOURS TO RADIUM EXPOSURE.

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The effect of radiation on the skin during control of the blood-supply was investigated by one of us.[1] The tail of the rat was used, and it was found that if the tail was blanched before radiation by winding rubber tubing up it, and kept blanched during the period of radiation by a ligature at the base, then the subsequent skin reaction was much less than when a normal tail was radiated. On the contrary, when the tail was made hyperæmic by being subjected to cold at 0° C., then the skin reaction following radiation was increased.

Jolly and Ferroux[2] obtained a similar result by tying the iliac artery, and studying the effects by X rays on the iliac gland: they found that tying the artery greatly diminished the effect of the X rays.

Why a diminished blood-flow results in a diminished sensitiveness, and vice versa, is unknown. It has, however, occurred to us that this fact may account for the small response to X-ray and radium treatment generally seen in anæmic patients; and the following experiments have been made to see whether rats rendered anæmic by bleeding show a diminished reaction to radium. Two sets of experiments have been carried out, one dealing with skin reactions, and the other with effects upon the growth of Jensen's rat sarcoma. The animals were bled by cardiac puncture, from 1 to 5 c.c. of blood being removed. Beta radiation was used from a square applicator of 60 mgrm., area 4 sq. cm., screen 0·12 mm. silver. Gamma radiation was used on six occasions, in which cases the applicator was screened with 3 mm. of lead in addition to the silver.

SKIN REACTIONS.

When the skin on the clipped flank of a rat is given an exposure of one hour to the applicator already described, an erythema occurs on about the tenth day. Erythema is, however, an evasive sign, coming and going according to whether the rat is warm or cold. Desquamation of the epithelium and falling of the hair is the next occurrence, on about the thirteenth day. When the epithelium desquamates, a moist surface discharging serum usually results. If the reaction is not so severe, a crust of dried serum forms, and in any case the crust forms as soon as the moist surface begins to heal. Later the crust falls off, leaving a smooth glossy hairless skin, and finally the hair grows again.

Thus the formation of a moist surface (M.S.) and the falling out of the hair (H.O.) occur early, or late, or not at all, according to whether the reaction

is severe or mild. Afterwards the formation of a crust (Cr.), the falling of the crust (Cr.F.), and the re-growth of hair (H.G.), occur in this case late or early according to whether the reaction is severe or mild. The experiments consisted in exposing the flank on one side to the applicator, then bleeding the rat, and exposing the opposite flank to a similar dose of radiation. In the first set five rats were used; their weight, the amount of blood taken, and the minutes exposure to β radiation are given in *Table I.*

Table I.

Rat	Weight	Blood Taken	Radiation
	Grm.	c.c.	Mins.
1	250	1·5	60
2	100	1·75	60
3	180	2·0	50
4	95	2·0	60
5	250	2·5	60

The skin reactions are given in *Table II*, the figures representing the number of days after radiation that the skin reactions occurred; for instance, taking the case of the first rat on the control side (C), a moist surface (M.S.) occurred on the thirteenth day after radiation, the hair fell (H.O.) also on the thirteenth day, a crust (Cr.) formed on the seventeenth day and fell off (Cr. F.) on the twenty-second day, the hair re-grew (H.G.) on the thirty-fourth day.

Table II.

Rat		M.S.	H.O.	Cr.	Cr.F.	H.G.
1	E	—	15	—	—	28
	C	13	13	17	22	34
2	E	—	23	—	—	36
	C	20	20	28	36	42
3	E	13	13	15	?	36
	C	13	13	17	?	36
4	E	—	28	—	—	31
	C	20	20	23	28	39
5	E	16	16	20	23	31
	C	13	14	20	36	38

In the case of the side radiated after bleeding (E) the reaction was much less, there was no moist surface or crust formation, the hair fell (H.O.) on the fifteenth day, later than on the control side, and the hair re-grew (H.G.) on the twenty-eighth day, much sooner than on the control side. The table shows that, with the exception of No. 3, where there is only a small difference, the skin reactions are decidedly diminished by bleeding the animal.

A similar set of experiments was carried out with γ radiation using six rats. The details are given in *Tables III* and *IV*; in this case different rats were used as controls, since it was not possible to give a rat two doses of 15 hours' radiation.

Table III.

Rat	Weight	Blood Taken	Radiation
	Grm.	c.c.	Hours
1 E	145	2·2	16
2 C	145	No bleeding	16
3 E	270	4	15
4 C	285	No bleeding	15
5 E	245	5	15
6 C	250	No bleeding	15

Table IV.

Rat	M.S.	H.O.	Cr.	Cr.F.	H.G.
1 E	—	20	—	—	24
2 C	20	20	22	?	45
3 E	—	—	—	—	—
4 C	19	19	21	24	38
5 E	—	22	—	—	38
6 C	—	19	—	—	44

The tables show that the reaction of the skin to γ radiation is reduced by previous bleeding of the animal.

In the next set four were radiated on both flanks but without any intermediate bleeding, in order to make sure that radiation on one side did not effect the sensibility of the skin of the other, apart from bleeding the animals. The results, given in *Table V* show that there was no difference in sensitiveness.

Table V.

Rat	Weight	Radiation	M.S.	H.O.	Cr.	Cr.F.	H.G.
	Grm.	Mins.					
1 Right	60	60	—	15	—	—	30
1 Left		60	—	15	—	—	31
2 Right	250	50	—	18	21	24	33
2 Left		50	—	18	21	25	33
3 Right	90	60	13	13	15	30	?
3 Left		60	13	13	15	30	?
4 Right	100	60	—	16	15	19	29
4 Left		60	—	16	15	22	29

Fig. 360 illustrates the results which are obtained. It shows the right and left sides of two rats which were radiated for one hour on the flanks, on the left side before bleeding, and on the right immediately after bleeding. On the left side ulcers are seen; on the right no skin reaction is visible.

The hair has been cut with scissors on both sides. The rats weighed 95 and 100 grm.; 2 c.c. and 1·75 c.c. of blood were withdrawn from the heart. The photographs were taken twenty days after radiation.

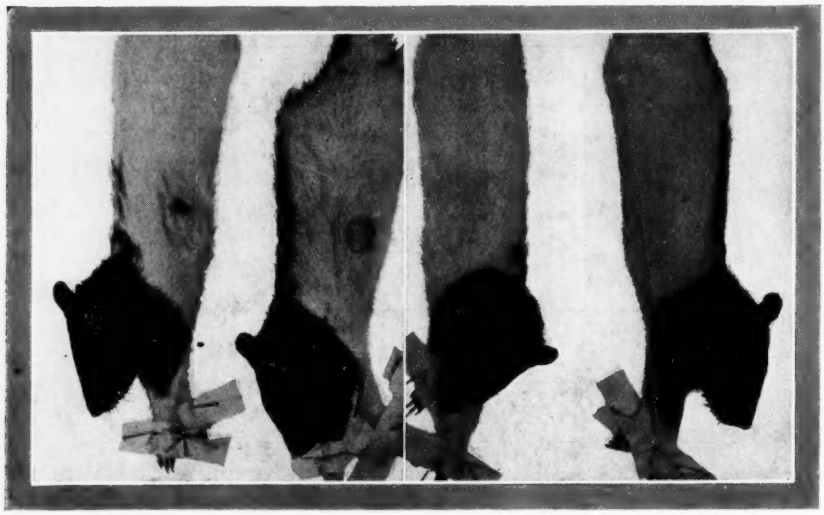

FIG. 360.—Photographs of rats twenty days after radiation. (*See text.*)

TUMOUR REACTIONS

Rats were inoculated on both flanks with small pieces of Jensen's rat sarcoma. When the grafts had grown into measurable tumours, the larger of the two was given an exposure to β radiation, the animal was then bled, and then the other tumour was given a similar exposure. Subsequently the

Table VI.

RAT	WEIGHT	RADIATION	BLOOD TAKEN	TUMOUR
	Grm.	Mins.	c.c.	
1	55	35	1·5	Grew
2	110	35	1·0	Grew
3	75	35	2·0	Grew
4	?	45	0·8	Grew
5	?	45	1·0	Grew
6	?	35	1·0	Grew
7	85	20	3·0	Diss.
8	110	20	2·25	Diss.
9	115	30	1·2	Diss.
10	95	20	2·0	Diss.
11	110	35	1·75	Grew

tumours were measured at intervals of a few days and the superficial area in square millimetres was obtained.

Eighteen rats were subjected to these experimental conditions, and in the case of eleven animals there were no decided differences in tumour growth

on the two sides. *Table VI* gives the weight of the animals, the amount of radiation, and the number of cubic centimetres of blood withdrawn. In four cases both tumours rapidly disappeared, so that differences in growth-rate could not become manifest. In the other seven cases the tumours grew

Table VII.

Rat	Weight	Radiation	Blood Taken
	Grm.	Mins.	c.c.
1	95	20	1·75
2	90	20	2·0
3	95	20	3·0
4	90	20	2·6
5	110	35	1·75
6	?	35	1·25
7	?	25	1·0

at an equal rate; in no case did the tumours radiated after bleeding grow more slowly than the tumour radiated before bleeding.

In the case of seven animals which showed differences in growth-rate, charts are given, and the experimental conditions are set forth in *Table VII.*

The charts (*Figs.* 361–367) show the rate of growth of the tumours, superficial areas in square millimetres (ordinates) being plotted against days after radiation (abscissæ). Each chart gives the growth of the two tumours in the same rat, the full line of the tumour radiated before bleeding, and the dotted line of the tumour radiated after bleeding.

The charts show that in all cases the tumours radiated after bleeding when the animals are anæmic grow faster than the control. This disparity in growth-rate, though it occurs when comparison is made between tumours growing in different normal rats, is only seen as a great rarity in tumours growing on the two sides of the same rat. The differences, therefore, must be due to the bleeding of the animals, since this is the

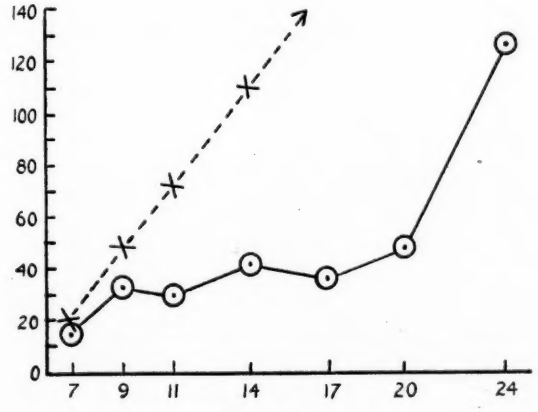

Fig. 361.

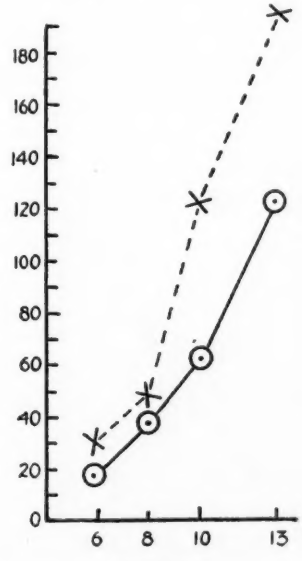

Fig. 362.

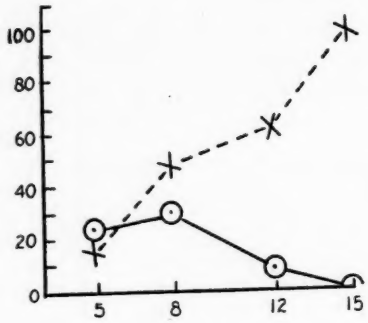

FIG. 363.

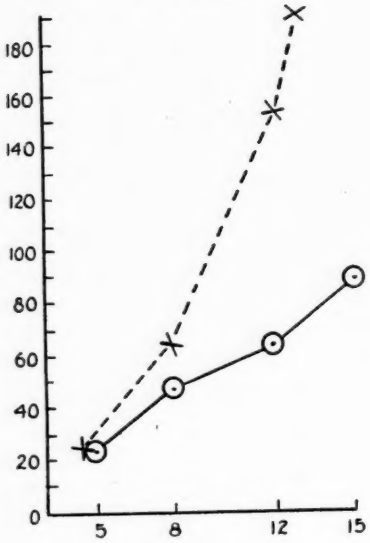

FIG. 364.

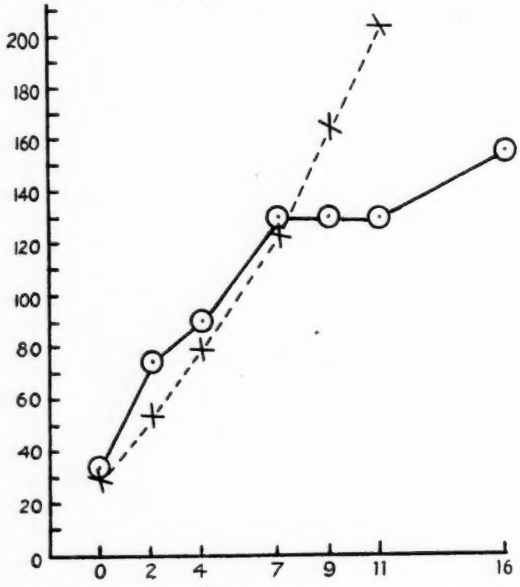

FIG. 366.

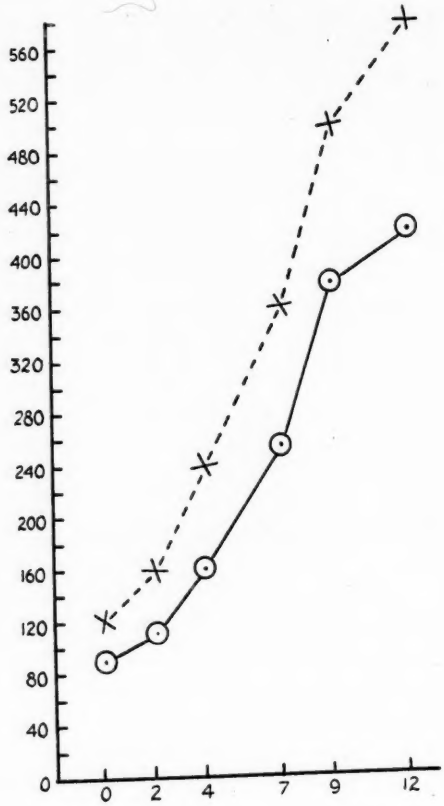

FIG. 365.

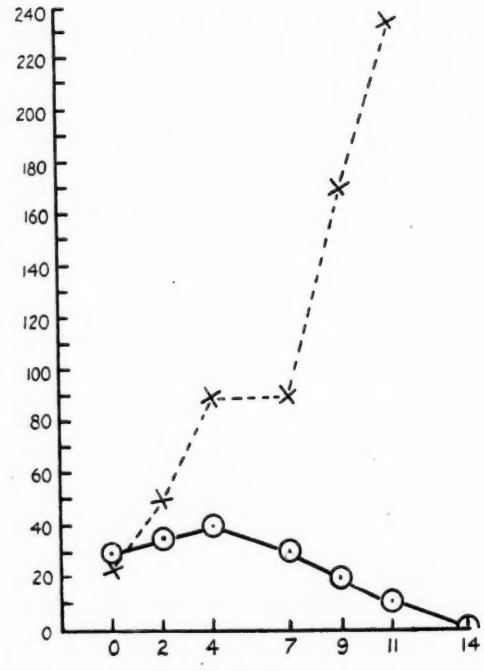

FIG. 367.

only variable experimental condition. In two animals, Nos. 4 and 8, not only was the growth-rate different, but whilst the tumours radiated before bleeding disappeared, that radiated after bleeding grew progressively.

The conclusion, therefore, is that tumours are rendered less sensitive to radiation by previous bleeding of the animal.

DISCUSSION.

Why stoppage of the blood-flow during radiation renders tissues less sensitive to radiation is unknown. The explanation which seems to satisfy best all the facts with regard to the action of radiation on tissues is that the permeability of the endothelial cells is altered during radiation so as to allow some toxin substance present in the blood to enter and damage the endothelial cells. Bleeding would thus be effective in reducing reaction to radiation by diminishing the blood-flow to the tissues. Secondary radiation from some constituent of the blood, such as hæmoglobin, can be ruled out, since a diminished reaction occurs when the blood-flow is stopped though the blood-vessels are left in a state of congestion.[1]

Whatever the explanation, the clinical bearing of these experiments is clear and important, and they support the clinical experience that anæmic patients do not respond well to radiation, and that tumours with a poor blood-supply react badly to radiation. It follows that before treatment with radiation every endeavour should be made to bring the patient's blood to as near normal as possible. We are of opinion that blood transfusion should be thought of in this consideration. Further, when a series of treatments with radiation is being employed, any anæmia produced by radiation should be vigorously treated during the intervals between radiation, and the blood condition brought back to the normal before further treatment is given.

CONCLUSIONS.

The bleeding of rats immediately before radiation renders the skin, and the tumour Jensen's rat sarcoma, less sensitive to β radiation than normal skin or tumours in unbled animals.

The radium used was on loan from the Medical Research Council.

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[2] Jolly and Ferroux, *Comptes rend. Soc. de Biol.*, 1925, xcii, 67 and 125.

THE PATHOLOGY AND TREATMENT OF TUBERCULOSIS OF THE KNEE-JOINT.*

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PATHOLOGY.

Tuberculosis of the knee is always secondary to active tuberculosis elsewhere, and in children almost always arises from long-established infection of the lymphatic glands, and though this primary lesion may have been present for a long time, the occurrence of the metastatic focus in the knee is a proof that it is active and that through it tubercle bacilli are reaching the blood-stream. Lymphatic infection, often previously unsuspected, is the root of the disease, forming a lesion inaccessible, insidious, and in issue more dangerous than that of the knee. For active lymphatic tuberculosis means tuberculous bacillæmia, frequent, or perhaps almost constant if the laboratory experiences with animals can be taken as a guide. Doubtless the degree and frequency of the bacillæmia depends on the activity of the disease in the glands; so, too, does the spread of tuberculosis within the thorax by progressive infiltration of the lymph-ducts.

We have, then, beside the knee, this lesion, capable of insidious advance, and continually giving out showers of tubercle bacilli which constitute an ever-recurring threat to life. And these are no idle threats, for the later are end-results investigated the higher is the rate of mortality, until it passes 20 per cent.

We learn from our experience that tuberculosis of the knee is not itself a mortal disease; if death comes, it is due to the development of tuberculosis elsewhere; and operative treatment of the knee, however necessary, and however successful, is applied to the flower and not to the root of the problem. With the flower gone, it is easy to forget the root; for with the removal of the focus in the knee goes the only obvious reason for prolonged general treatment in the open air. Indeed, there is grave risk of earning the old thrust, "The operation was successful but the patient died!" Only prolonged general treatment, followed by good environment through the years

* When I was asked to open a discussion on this subject before the Association of Surgeons—a subject which is of very special interest to orthopædic surgeons—I felt quite unable to do so adequately without the help of my colleagues; accordingly I circulated a questionnaire and thus learnt the opinions of fifty-five of my colleagues in the British Isles, Canada, the United States of America, France, Italy, Holland, and Sweden. They gave me generous and most valuable assistance; some, indeed, took a great deal of trouble in looking up cases and getting together figures. I am most grateful, and feel that this paper is valuable in so far as it represents the present-day views of experts on a subject about which we have learnt much in the last few years.

of lymphatic disease and tuberculous bacillæmia, will give the patient safety during the time he needs to kill or to encapsule *all the tubercle bacilli in his body.*

The commencement of a focus in or near a joint may be due to tubercle bacilli settling in an area devitalized by a blow or settling in such large numbers that they can survive without any such preparatory devitalization. I think from the medico-legal point of view the time relationship of injury and the appearance of signs and symptoms is critical. Probably, however, the number of bacilli sown, and the suitability of the soil, influence the rate of the development of the lesion.

A few years ago I was the unwilling subject of a valuable experiment in which the time data are reliable. On March 2, while hurriedly extracting with a long gouge some carious bone from the depths of a hip with severe pyogenic infection, I embedded the gouge deeply in the pulp and periosteum of my left middle finger. The wound healed per primam, and, with the danger of sepsis over and that of tuberculosis unsuspected, I gave the finger some hard work during the next few weeks. The area of the wound was a little tender, but no more than one would expect. It was not till *ten weeks* after the implantation that there was sufficient swelling and discomfort to make me feel that a diagnostic excision of tissue was advisable. This was done and one or two tubercle bacilli were found. *Seven weeks* later the tuberculosis began to spread up the tendon-sheath, a gland in the neck developed, and amputation of the finger was necessary.

SITE OF INFECTION.

The infection of the knee-joint may be: (1) In the synovial membrane; (2) In one or more foci in the bone on either side of the epiphysial cartilage. And where the disease originates in the bone the joint will sometimes show signs of *irritation* before it is *infected.* The site and extent of infection are of clinical importance: and by a careful study of stereoscopic radiograms it is possible to distinguish three groups, and to outline for each group the appropriate modifications of treatment.

Group I.—Extra-articular. With Osseous Foci irritating but not yet infecting the Joint.—As Calvé puts it, "In contiguity but not in continuity with the joint". One's first feeling is that prompt elimination of the focus by an extra-articular route is indicated to save the joint from infection. But Calvé urges caution; he fears that there may be a communication from focus to joint not shown in the radiograms, and that an extra-articular operation may lead to tuberculous infiltration of the wound track from the focus, which in the other direction communicates with the joint, forming a tuberculous sinus with the danger of secondary pyogenic infection of the track and the joint.

Extra-articular operation on a focus truly extra-articular will save a joint, but on a focus which falsely appears extra-articular may lead to its ultimate infection with pyogenic organisms. The choice between conservative and operative treatment in these cases must depend upon the confidence with which one can distinguish the focus walled off by healthy bone from the focus with the wall already softened by tuberculous infiltration. I think

that with good stereoscopic radiograms it is generally possible to distinguish these conditions. But when doubt remains the decision must be made on the same lines as that regarding arthropsy (*see below*), i.e., that operation is only safe after the age of 10 or so, for then in the event of the focus being found to open into the joint, excision can be carried out, and the disaster feared by Calvé avoided. (*Fig.* 368.)

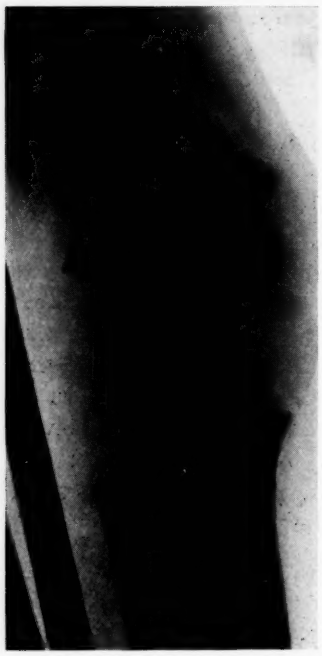


FIG. 368. — Extra-articular focus in the femur involving epiphysis and metaphysis. When first seen the knee was painful, swollen, hot, and tender, and almost fixed by muscular spasm. Early radiograms were negative. Treatment, conservative, from Nov. 6, 1928, to April 27, 1931, when a collection of inspissated pus was excised. This was shut off from its origin, which was therefore not explored. Healing per primam. Programme: prolonged protection by weight-bearing caliper. The joint itself appears to have escaped permanent damage, and there is prospect of free movement ultimately.

Group II. — Focal-articular. With Osseous Foci opening into the Joint and discharging Tubercle Bacilli into it.—Such internal fistulæ seldom if ever heal with a freely mobile joint. For movement will almost inevitably tear off the cap or seal and reinfect the joint. Fusion alone can give security; it remains to *choose the time*, and in young children to *await the age*, for operation.

The time will be chosen in regard to the age and the general and local condition, and no weight given to hopes of obtaining safe and permanent healing with good mobility. For these hopes have always been vague, and now the answers of the great majority of my colleagues agree that they are futile. I put the question: *Can you give me any evidence of the healing of an osseous tuberculous focus, which has opened into the knee, with retention of a freely mobile joint?* Of 40 who answer this question, 35 answer definitely "No", some adding, "I don't believe it ever occurs." Calvé says, "I do not know of any cases of an osseous focus open into the joint with restoration of normal mobility. The invasion of the joint is always followed by ulceration of cartilage, and then by definite loss of articular function."

It is true that five correspondents quote a total of 10 cases in 5 of which extra-articular operations have been done or sinuses apparently leading to extra-articular foci have appeared, and in the end free movement has been obtained. But these numbers are minute in relation to the thousands of cases covered. They represent very exceptional cases in young children. Fortunately, under the scheme of treatment I suggest, such cases will not undergo premature fusion, but will have ample time to demonstrate the promise of mobility before they reach the age for fusion.

On the whole I may take Elmslie's answer as representing the views of the great majority; he says: "No. I should say that when a bony focus has opened into the knee the best result obtainable is an ankylosis." Such a conclusion appears almost inevitable in view of the morbid anatomy; for while an endosteal focus may become walled off and the caseogranuloma

encapsuled, for this wall to form it is necessary that the focus be completely surrounded by living vascular material. When the focus is open to the joint on one side no such healing wall can form on that side. If the opening is *away from* the weight-bearing surface it can be capped by adhesions, and these will limit movement. Such an occurrence furnishes an example of the danger of limited movement, for the cap may be torn off by a sudden wrench. On the other hand, if the opening is *on* the weight-bearing surface it can only be capped by the opposite member of the joint. This form of natural healing is equally unsatisfactory, for it commonly results in an unsound fibrous ankylosis—fibrous rather than bony on account of the persistence of the articular cartilage in the face of tuberculosis; and unsound because the strain falls on the caseogranuloma.

All these considerations lead one to the conclusion that: *A tuberculous knee with bony foci communicating with the joint should be excised, and the arthrodesis should be performed at a time chosen in view of the age, local and general condition.* (*Fig.* 369.)

FIG. 369.—Unsound natural ankylosis in a man of 60. Skiagram showing pathological fracture (minor injury) in neighbourhood of old tuberculous disease which had begun fifty-five years before. Active recrudescence followed and amputation was necessitated. A remarkable example of persistent latent disease, and the failure of natural ankylosis.

Group III.—Non-focal. Without Visible Osseous Foci, or if there are bone lesions they are small superficial foci round the edges of the articulation rather than fistulæ opening into it, i.e., *the tuberculosis is radiologically synovial*, though perhaps 'pseudo-synovial'. This group may be termed '*non-focal*'. My own figures and experiences in this group have convinced me that in young children purely conservative treatment is very well worth while and should be most carefully and continuously carried through. Indeed, it appears that there is for them good hope of recovery with complete or almost complete movement (*see Table I*). To ascertain the views of others I put the question:—

Are there any data or conclusions as to the occurrence of purely synovial tuberculosis of the knee, its histology, and its prognostic significance?

That purely synovial tuberculosis exists has been demonstrated *many times at operation.* For while excising a knee and aiming at a complete synovectomy, a surgeon inspects completely the articular surfaces of femur and tibia. Now 38 out of 41 of my colleagues who answer this question

agree as to the existence of purely synovial infection, and most add that the outlook is relatively favourable. Only three out of the 41 say either that synovial tuberculosis always goes on to osseous, or that minute osseous foci always exist round the synovial edges. The latter point is of no *practical* importance—it suffices us to know that when in young children no bone cavities can be seen throughout a series of radiograms, and when these cases are treated well enough and long enough, the majority will recover with full movement. Soutter, of Boston, with 9 synovial cases out of 45, reports 3 with full movement, 3 with fair, 3 with unsound ankylosis. Fraser reports that of his synovial cases 17 per cent had free movement, 56 per cent limited movement, 21 per cent some form of ankylosis, and that 6 per cent subsequently came to excision. I do not know to what extent these figures refer to end-results. For my own cases, *see Tables I, II.*

Now and then a case which appears hopeful under conservative treatment will ultimately come to excision. Nevertheless in the non-focal group one can peacefully carry on with conservative treatment till free movement is achieved or failing that excision becomes inevitable. For the time is not wasted and cannot be better spent.

Table I.—CHILDREN WITH 'NON-FOCAL' TUBERCULOSIS OF THE KNEE. TREATED AND WATCHED FOR 5 YEARS OR MORE.

(*Wingfield Orthopædic Hospital.*)

	No. of Cases (14)	Period since Set Free from all Splintage or Restraint
Result: Full movement	9	Years $2\frac{1}{2}$, 4, $6\frac{1}{4}$, $2\frac{1}{2}$, 2, 3, $3\frac{3}{4}$, $2\frac{3}{4}$, $2\frac{1}{2}$
Result: Good movements (i.e., 180° to above right angle)	2	Years $3\frac{3}{4}$, $3\frac{1}{2}$
Under test	1	Free, promising, but time insufficient
Still under treatment	1	Promising
Excised, sound union	1	

Table II.—DETAILS OF THE 9 CASES WITH FULL MOVEMENTS SHOWN IN *Table I.*

	Age	Plaster Spica	Caliper and Guarding Plaster	Caliper only	Total Period of Splintage	Period since Set Free
	Years	Months	Months	Months	Years	Years
1	9	7 + 5 = 12*	6 + 36 = 42*	28	$6\frac{3}{4}$	$2\frac{1}{2}$
2	2	20	13	—	$2\frac{3}{4}$	4
3	11	9	21	18	4	$6\frac{1}{2}$
4	$1\frac{10}{12}$	7	15	7	$2\frac{1}{2}$	$2\frac{1}{2}$
5	5	4 + 10 = 14*	5 + 9 = 14*	9	3	2
6	$1\frac{3}{12}$	36	4	27	$5\frac{1}{2}$	3
7	9	8 + 8 = 16*	4 + 8 = 12*	21	4	$3\frac{3}{4}$
8	12	12	9	4	2	$2\frac{3}{4}$
9	7	8	?†	?†	?†	$2\frac{1}{2}$

* *Two periods*—second due to *signs of commencing reactivity after remitting guarding plaster* in each case.

† Owing to defective notes these time periods cannot be ascertained.

N.B.—All children with reasonably good homes become out-patients during the second period.

DIAGNOSIS.

Now only prompt, effective, continuous, and prolonged treatment will prevent synovial disease from becoming osseous. Yet the nature of the disease is such that an early certain diagnosis is often impossible: therefore we must put up with a provisional diagnosis and act on it as quickly and stringently as if it were certain. Indeed, treatment and diagnosis must for a time run concurrently; so that it is impossible to avoid some consideration of diagnosis, though it is not included in the title of the discussion.

Tuberculosis of the knee is characteristically a monarticular arthritis with a very insidious onset. Generally the first thing noticed by the patient or parent is an interference with function and some swelling, rather than pain. Indeed, pain and tenderness are slight at first, the characteristic features being limitation of the full range of movement and a swollen, warm, and somewhat tender joint, with the enlargement due to swollen synovial membrane rather than to fluid. Inquiry may reveal: (1) The likelihood of human infection; (2) Previous manifestations of tuberculosis; (3) Some loss of health and vigour; (4) A history of an injury to the knee from six to twelve weeks previously, with a normal joint during most of the interval.

Both Calvé and Ombredanne mention enlargement of the regional glands in the groin, and, indeed, emphasize this as an aid in diagnosis. The muscular atrophy is often out of proportion to the history and the X-ray evidence. And while positive X-ray evidence is of very great value, negative by no means excludes tuberculosis. But in early cases it is impossible to make a diagnosis in the out-patient room. Therefore we must be content with a provisional diagnosis, for we cannot wait for the development of a conclusive clinical or radiographic picture. That is the very thing we want to avoid, and I feel this all the more keenly since I have learnt from my own end-results that in children under 10 without X-ray evidence of osseous foci early and very long-continued immobilization has led to a complete cure with full movements in the majority of cases. I think there had been a drift toward the feeling "they will all come to excision sooner or later". Fortunately we now know that this is untrue; but this knowledge adds to the urgency of our duty. Therefore I suggest that a provisional diagnosis of tuberculosis should be made on this slight clinical picture, whether radiograms reveal pathological changes or not; the knee should be immobilized at once and the patient admitted without delay for investigation.

On admission the patient is thoroughly examined, tonsils are removed if unhealthy, and the bowels regulated. Personally I have not found a blood-count helpful toward a diagnosis, either of tuberculosis itself, or of the cause of an arthritis simulating tuberculosis, and this I find is the general view. But I think that one should apply one or more tuberculin tests, preferably the intradermal (Mantoux), the Wassermann or sigma, and in some cases the gonococcal complement fixation test. The Wassermann or gonococcal tests have value when positive, though they do not, of course, eliminate the possibility of tuberculosis. (*Figs.* 370, 371.) Positive tuberculin tests have no value except perhaps in very young children, but negative tuberculin tests have great value. Let me quote Waldenström, of Stockholm, who says:

"In all cases I do the von Pirquet and Mantoux tests; if positive they give no help in the diagnosis; if negative, they tell us that the patient is free from tuberculosis—that is, also, in the knee." If, then, the tuberculin tests are positive and the other tests negative, we are no further on and must choose between a clinical diagnosis based on the march of clinical signs and radiograms and a diagnostic arthrotomy. The points on which such a choice can be made follow later. Of course if pus can be aspirated, a simple and decisive substitute for arthrotomy is offered and should be taken; but

FIGS. 370, 371.—Girl, aged 12. Syphilitic osteochondritis. Clinical condition resembled tuberculosis, and faulty diagnosis of tuberculosis was made. Subsequently Wassermann + + + +. Note relative density round epiphysial disc of femur.

in my experience pus is very rarely to be found in early doubtful cases. Any clear or amber fluid there may be gives little or no useful information.

In the non-focal group, then, we are without radiographic help, and in young children for whom arthrotomy is inadvisable (*see later*) provisional diagnosis and immediate treatment is the only safe way of coming to a diagnosis; yet the early signs and symptoms are so slight and unalarming that it is hard to persuade oneself, and still harder to convince the patient and parents, of the necessity of his admission to hospital. One is tempted to hesitate, to try a month or two in plaster, and so on. This is a mistake.

Hesitation has led many a child down the broad and easy way that leads to destruction—of the knee-joint.

To hesitate is to be lost, for after a month or two of immobilization the knee appears almost normal. This disappearance of signs and symptoms is indeed the great trap in the diagnosis and treatment of tuberculosis of the knee. It is so tempting to treat the signs and symptoms and to remit treatment when they disappear. And synovial tuberculosis is only too ready to enter into this game of cat and mouse. Indeed, the disappearance of all signs of inflammation after a few weeks or months of immobilization should be regarded as part of the normal clinical picture of synovial tuberculosis.

Negative clinical and pathological information must be confirmed by the behaviour of the joint during test periods of gradually progressive lessening of the rest which has been enforced upon the joint. The patient should be *in hospital* or at least under good conditions and strict discipline during this test period. If the signs quickly disappear under immobilization—for example, have quite gone in six weeks—we remit strict immobilization but retain the patient in bed for Thomas's tests. If no sign of recurrence follows this freedom, further freedom is allowed, still under strict observation. And in a week or two more the child who has had an attack of transient arthritis from pharynx or intestine has set himself free and returned to normal life. On the other hand, any return of warmth, swelling, or limitation of movement indicates tuberculosis. All this applies to the child, not to the adult, to the synovial case, not to that with bone foci, and thus, it will be realized, to the one group of cases in which our care can be rewarded by a completely perfect recovery.

The Value of a Clinical Diagnosis.—Some years ago there was a reaction against too ready a diagnosis of tuberculosis of joints on insufficient grounds, and many demanded that the diagnosis should be restricted to those in which the radiographic evidence was very strong, or, better still, those in which tubercle bacilli could be demonstrated. This was a wholesome and corrective phase, but I have always felt that it was intrinsically unsound, so I asked my colleagues: *What evidence do you consider sufficient to make the diagnosis of tuberculosis?* Of 46 who answer this question, 39 are in general content with clinical diagnosis, but glad to have it confirmed whenever a chance of doing so without risk comes. Only 7 out of the 46 insist on a histological report or the finding of bacilli in fluid or tissues by the bacteriologist or the guinea-pig.

Diagnostic Arthrotomy.—Now, hitherto, the indications for a diagnostic arthrotomy have not been settled; hence my question: *Do you do a diagnostic arthrotomy? If so, what is your procedure?* That the indications had not yet been agreed on was clear from my answers: "Often or always", 15; "No or never", 15; "Rarely", "Occasionally", "Only in selected cases", 23. But I think my collaborators have enabled me to answer the question and to define clearly the indications and contra-indications. To begin with, it should be understood that diagnostic arthrotomy is not without danger both to the patient and to the diagnosis.

First as to the diagnosis—false negatives are common, for the histologist, bacteriologist, or guinea-pig returns a negative if the material supplied is

inflamed but not *infected* by the tubercle bacilli. For there is no characteristic histology *unless tubercle bacilli are present in the microscopic field* (the bacilli need not be *demonstrated*, for that is technically much more difficult than the recognition of the histology characteristic of their presence). This is analogous to the radiological position, for there is no characteristic radiographic picture unless the tubercle bacilli have been working in a radiographic field—that is, unless there are foci in the bone. And purely negative reports from the histologist, bacteriologist, and guinea-pig ought to be classified with negative reports from the radiologist.

Secondly as to the danger to the patient—the following are quotations from the reports of three of my collaborators.

First there is Osgood, of Boston, who writes that he does a diagnostic arthrotomy "only in very infrequent cases. Have been troubled by the occurrence of sinuses along the tracts of incision, appearing often several months after complete healing of wound. These unfortunate events have occurred chiefly in biopsies of the hip-joint. In early cases of suspected knee-joint tuberculosis, danger exists, and material excised may be indeterminate unless thorough exploration of the joint is made."

Then Ober, also of Boston, who has probably seen some of Osgood's cases, says: "I do not do a diagnostic arthrotomy except when I feel sure that it is not tuberculosis. At the New England Peabody Home we have had some very bad results as a result of a biopsy, tubercle bacillus invading the whole area of the wound, including the skin and scar about the wound, and finally breaking down; and these biopsies were done by those who have strongly advocated biopsy. Personally I consider the result of the biopsy very detrimental to the child. One ought to be able to diagnose syphilis and osteomyelitis from other elements and without biopsy. Arthritis is probably more common in children than we have suspected, so that I would say a biopsy would be done in the presence of a negative tuberculin reaction, not in the presence of a positive one."

Thirdly there is Soutter. He rarely does arthrotomy, saying: "I have followed the method of arthrotomy for diagnosis of tuberculosis, and the men that have been doing it largely here are not doing it to any great extent. It should not be done in tuberculosis of the joint without good reason, and then only when the disease has already involved the joint."

It is clear that the danger to the patient is tuberculous infiltration of the wound track outwards, followed by pyogenic infection inwards. The former is a slow affair and can always be prevented by arthrodesis within a week or two of the diagnostic arthrotomy. It must be true to say that diagnostic arthrotomy is *free from risk only if a positive diagnosis of tuberculosis will be quickly followed by fusion*, and *dangerous only when conservative treatment will be continued despite a positive diagnosis.*

I suggest that in young children a clinical diagnosis, carefully tested and reviewed, is all that one needs; arthrotomy is contra-indicated, for it is risky and unnecessary. The persistence of a chronic decalcifying arthritis, with or without bony foci, is sufficient for all practical purposes.

Indications for Diagnostic Arthrotomy.—Diagnostic arthrotomy is indicated:—

1. In young children—*never*, except perhaps when repeated tuberculin tests have excluded tuberculosis and some other cause is sought; this is Ober's opinion. Incidentally it may be mentioned that an arthrotomy is not the best way of distinguishing a hæmophilic knee. One of my collaborators mentions with pious gratitude that he was only prevented from this by noticing a bruise.

2. In cases radiologically non-osseous—only when the patient is ripe in stage and in age for fusion.

3. In adults—always, as the first step of an excision.

When an arthrotomy is done, attention should be paid to the following points: (1) Ample incision into the joint for inspection of synovia and articular surfaces; or, if the signs are localized, a smaller incision in that region. (2) Discovery of the most diseased part and removal of a generous sample of this for histological examination. (3) It is well to ask the pathologist also to be generous in his supply of material to each guinea-pig, for the infection may be slight and scattered. Fraser suggests that two guinea-pigs are better than one. I agree, but I would rather give one guinea-pig a big dose than let two split it between them.

Note.—If for some extraordinary reason an arthrotomy is to be done on a case which may prove tuberculous, and which, if it does prove tuberculous, will be treated by conservative means, the edges of the capsule should be accurately protected before the synovia is opened, and very accurately sutured afterwards.

It is true that the ardent arthrotomist has served a very useful purpose by proving that knee-joints certainly infected with tuberculosis may run their course without radiographic evidence of any destructive lesion, and ultimately recover with full movement. This we now know, and for the future we can confine arthrotomy to those cases in which it will be helpful and harmless.

In my questionnaire I asked for opinions as to the results of the bacteriologists' reports on histology, on the finding of tubercle bacilli in tissues or pus, and guinea-pig inoculation. Now in Oxford we are very fortunate in having in Dr. A. D. Gardner a bacteriologist who has made a special study of this subject. He has given me the following table dealing with examination of synovia removed at arthrotomy in 18 cases which proved tuberculous.

Table III.

Positive Histologically .. .. (One case was negative histologically and by guinea-pig, but proved by finding T.B. in smear)	17 (94 per cent)
Positive by Guinea-pig Test	13 (72 per cent)
Positive histologically / Negative by guinea-pig	4 (22 per cent)
Negative histologically / Positive by guinea-pig	0

N.B.—For histology, from one to four selected blocks of tissue were prepared, according to whether the tissue looked obviously tuberculous or doubtful.

On the whole, the opinions of my colleagues put the guinea-pig above the pathologist, but Dr. Gardner's experiences show that a pathologist

experienced in tuberculous material, who is prepared to take time and trouble, is at least as good as a guinea-pig in finding the bacilli in pus and furnishing a diagnosis from tissue. For a portion of tissue sufficiently infected to give a guinea-pig tuberculosis will be histologically characteristic of tuberculosis.

Almost all my correspondents report false negatives. Those who want to pursue this subject further should read Ghormley's[1] interesting paper.

TREATMENT.

GENERAL TREATMENT.

As the patients suffer from tuberculosis, of which the knee is only one and the less dangerous lesion, they all need general treatment by physical rest and metabolic stimulation, heliotherapy, a well-chosen and varied diet, and enlivening environment.

In adults this general treatment is *preparatory to operation*; but it is wise to explain to the patient that the operation will not eliminate the need for general treatment afterwards. The infection of the knee is a proof of tuberculous bacillæmia, and another metastatic lesion is likely unless the source of the bacilli is dried up and the patient's resistance raised by general treatment. Good treatment will hasten, but nothing can cut short, the process of healing. Indeed, one wonders whether after early middle age the glandular disease ever heals quite soundly. Second lesions are unhappily common.

LOCAL CONSERVATIVE TREATMENT.

The local conservative treatment consists in keeping the joint quiet and cool. Any heat or disturbance, e.g., diathermy or massage, applied to the joint is extremely harmful. As to the methods of immobilization, the great majority agree that so long as the joint is warm it should be completely immobilized, and that the best method for this period is a plaster spica including pelvis and foot. For example, Putti advises "rigorous immobilization in plaster for a long time".

Deformity due to soft tissue changes can be corrected gradually and easily as the inflammation dies down. Fixed deformity can be left until the fusion operation, and it is very possible, as MacLennan believes, that the healing is quicker with the knee somewhat flexed.

Some weeks or months after the knee has become cool a caliper with a guarding plaster can be applied and the child allowed up. Later the guarding plaster can be left off, but the caliper must remain for years. I am sure that it is true that no harm follows wearing a caliper unnecessarily long. Where the disease is synovial (or pseudo-synovial) free movement often follows long-continued and continuous immobilization. Immobilization for years does not lead to fixation, whereas lack of immobilization or a break in its continuity is liable to lead to extension and reactivity of the disease, and to destruction of the articular cartilage on whose integrity joint function depends. *Permanent loss of movement is the result of disease, or the operation it necessitates, never of immobilization.* A study of several series

of radiograms of non-focal knees has convinced me that the articular ends of femur and tibia usually develop normally during the years that they are immobilized. Free and normal movement returns of itself gradually and progressively if the knee is set free only after the disease is soundly healed.

The secret of the gratifying results which are being obtained by conservative treatment in children with synovial tuberculosis of the knee is threefold: (1) The effectiveness of immobilization; (2) The continuity of immobilization so that there is no re-arousal of the tuberculous inflammation; and (3) The length of immobilization.

The 'non-focal' knee should be kept in a caliper at least a year, probably two, after all signs and symptoms of activity (such as warmth, swelling, and tenderness) have disappeared, if it is to be completely and permanently safe. And in those with bony foci communicating with the joint there is no advantage in early excision (and there are some dangers). For the knee goes on quite happily in a caliper. And the longer the wait, the readier are the bones for fusion, as a result of recalcification, and fuller ossification of the epiphyses. The age at which fusion will be done in any particular case depends partly on the age of onset and subsequent length of efficient treatment, and on the recalcification of the bones as shown in radiograms.

In adults and adolescents, on the other hand, there is no advantage in continuing *local* conservative treatment once the activity of the disease is over. Radical local treatment is then followed by continued general treatment.

In short, the local disease, with varying distribution (synovial or bony) and varying activity, demands varying methods of immobilization; but the general condition is the main factor which determines the length of hospitalization, and of after-care.

OPERATIVE TREATMENT.

Excision, Fusion, Arthrodesis.—

1. There are only two safe end-results for a tuberculous knee—free movement or bony ankylosis.

2. Free movement is not obtainable in adults, and in children only to be sought when there is no radiographic evidence of osseous foci communicating with the joint.

3. In adults, then, ankylosis is the aim, but without operation ankylosis is delayed, very unlikely, and, if it occurs, dangerously unsound.

If these are true axioms, fusion is indicated in all cases of proved tuberculosis of the knee-joint, except in children without radiographic foci communicating with the joint, and cases in which it is contra-indicated by age or complications.

It is true that Rollier says that excision is never necessary. This extreme advocacy of conservative treatment is unsupported by any of my colleagues.

It remains to define the operation, to consider when and how it should be done, and what are the dangers and contra-indications. The modern operation, whether it is called excision, fusion, or arthrodesis, is designed: (1) To promote bony ankylosis; and (2) To remove all diseased parts which are accessible without either interfering with growth or lessening the prospect

of bony ankylosis. The dangers of the operation are listed later. In the main they are due to operating on cases *unduly early, unduly young,* or *unduly septic.*

INDICATIONS FOR EXCISION.—

1. *Age.*—All adolescents over 15 and adults under 50 or 60. Children who have osseous foci communicating with the joint, when they attain 'excision age'.

2. *Stage.*—(*a*) In *adolescents and adults.* Only after the general illness and local activity have been checked by general treatment and immobilization. (Incidentally during this period the various diagnostic tests can be carried through.) (*b*) In *children with osseous foci.* Only when conservative treatment is complete and the patient is old enough (? 10, 12, 14, 16—opinions differ). (*c*) In *children without osseous foci.* Only when the patient passes puberty without the promise of free movement.

3. *Confirmation of Diagnosis.*—After the diagnosis has been confirmed by arthrotomy which, if the naked eye suffices or frozen sections are available, can be the first step of the excision, or, if microscopic evidence is needed, can precede excision by a week or two.

CONTRA-INDICATIONS TO EXCISION.—These are: (1) Childhood; (2) Unchecked activity of the disease, general or local; (3) Active phthisis; (4) Extensive involvement of the femoral shaft; (5) Active septic infection of sinuses, despite preparatory drainage or free exposure, scraping, and packing.

In answer to my question whether a sinus should be looked upon as a contra-indication to arthrodesis 22 surgeons say "No", and express no fears; 14 qualify their negatives, indicating that they do consider it dangerous to excise if the infection is active—for example, Osgood says, "If infected danger must be appreciated", and Calvé says, "I do not consider the presence of a sinus a contra-indication to resection if not accompanied by febrile symptoms, and the knee as a whole is dry. In febrile cases or bad general condition—wide resection of tracks with removal of sequestra—never *resection* (of the joint)."

An American surgeon considers an infected sinus a contra-indication, saying, "My experience shows that it is very dangerous." An Englishman, "Yes, two cases, both did very badly." At the Wingfield Hospital only one excision has been done in the presence of an infected sinus. The patient, a middle-aged woman, died of pyæmia. Theoretical considerations and the experience of this case make me shrink from excision in the presence of a sinus.

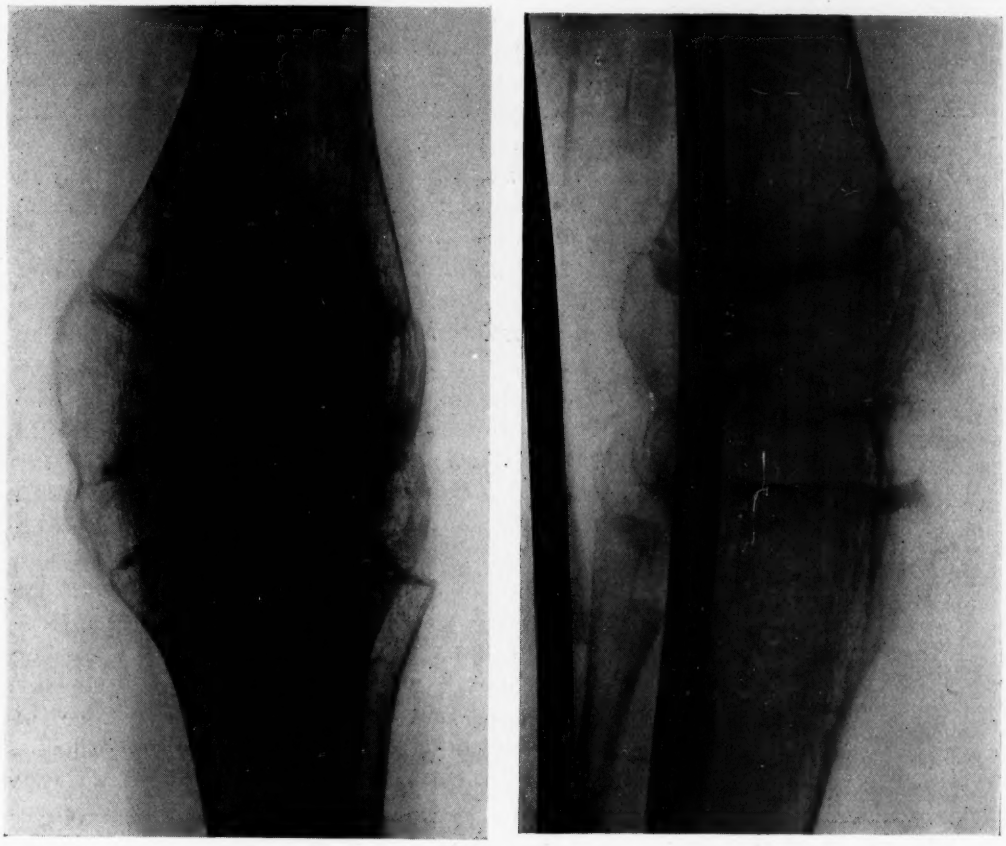
I feel that Calvé's method of preliminary laying open and resection of the sinus tracks and perhaps paraffin flavine dressings for a time is wise. I am in favour of very thorough drainage and continued immobilization. If in spite of this the sepsis and the tuberculosis remain persistently active, I would amputate rather than excise, for I must admit to being altogether averse from laying open in the presence of sepsis all the raw absorbent surfaces of bone and tissue entailed by excision and synovectomy.

TECHNICAL POINTS.—

1. *Tourniquet and Towelling.*—I think a tourniquet is valuable for the earlier stages of the operation, but it should be *removed for hæmostasis before* any sutures, grafts, pegs, or nails are applied. The tourniquet makes the

operation easier for the surgeon, and the patient loses less blood and must surely suffer less from toxæmia and bacillæmia. The towelling should be so folded and clipped round the limb above and below the knee that the leg is stockinged and the thigh trousered; otherwise gaps appear when the knee is fully flexed.

2. *Synovectomy.*—In answer to the question whether we should aim at complete synovectomy, 31 surgeons answered "Yes", 13 said "No", and 2 answered "In adults only". Of the 13 "Noes", most aim at removal of *all*



FIGS. 372, 373.—Boy aged 13. Illustrating minimal removal of bone.

grossly diseased material. Personally I always aim at a complete synovectomy in adults (and this I believe to be an essential safeguard) and at any age if the synovia appears diseased. In children, when the operation comes—properly—at the end of conservative treatment, fusion is needed, synovectomy not so; and I doubt whether there is any advantage in removing the suprapatellar pouch in these cases.

3. *Division of all Ligaments.*—After removal of the suprapatellar pouch, complete division of the mesial, lateral, and crucial ligaments facilitates the posterior synovectomy.

4. *Osseous Foci.*—If there are osseous foci, I scrape them out with a

sharp spoon. There is no need to level the bone down to their bases, and there are great disadvantages in doing so.

5. *Preparation of Bone Surfaces.*—Most of my colleagues use a broad saw and cut plane surfaces. Albee uses a narrow-bladed saw and shaves the femoral condyles, then cuts a coronal trough across the tibial tuberosities to fit. For adults this is excellent, but for children I prefer to use gouges and to shape each condyle to a ball and each tuberosity of the tibia to a shallow socket, leaving the bared tibial spines as a tongue fitting into the bared intercondylar notch. There is less removal of bone and the apposition is more secure (*Figs.* 372, 373).

6. *Angle.*—I am surprised to note that a few surgeons still advocate a straight knee. Most, I think, choose the angle to suit the sex and occupation of the patient. Probably an angle of about 150° is a good average for an adult. But the younger the patient, below 18, the less the angle that can safely be allowed on account of the strain imposed upon the tibial epiphysis by ankylosis in flexion.

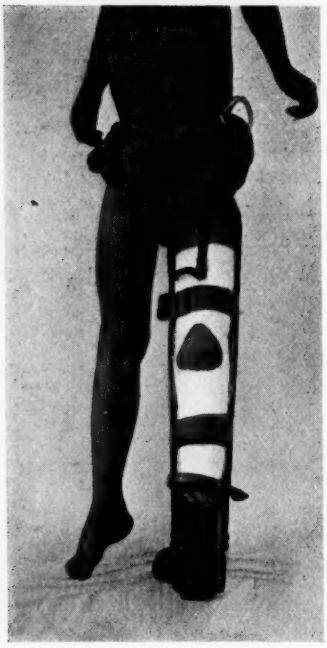


FIG. 374.—Caliper and guarding plaster. Note suspensory strap from caliper ring to buckle fixed in plaster.

7. *Removal of Tourniquet.*—The tourniquet should be removed as soon as synovectomy has been completed and the bone-ends have been prepared. All bleeding points are then tied.

8. *Internal Fixation.*—Most surgeons who cut the bone-ends square use some form of internal fixation. The favourite methods are decussating bone-pegs or long decussating nails which project from the plaster and are removed several weeks later. Some use the bared patella, but if one removes very little bone it must be used as a free graft. Tibial and hinged osteo-periosteal flaps are mentioned. But with the ball-and-socket method apposition is easily maintained, and alteration of the angle of flexion does not interfere with the area of bony contact: so that there is little need for internal fixation.

9. *Drainage.*—Drainage for twenty-four hours is always advisable.

10. *Method of Immobilization.*—A plaster spica including pelvis and foot is almost universally used. Flying buttresses of plaster or ferro-plaster enable one to cut a large window at once for dressing the wound and removing the blood drains.

11. *Length of Immobilization.*—It seems wise to leave the patient in the spica for ten or twelve weeks, then use a guarding plaster with a caliper flexed to fit until X-rays show sound union. (*Fig.* 374.)

THE RESULTS OF EXCISION.—

Failure may be due to:—

1. Operating while the *disease is active*, the *patient ill*, and the local resistance so poor that local tuberculous recrudescence takes place.

2. *Active tuberculosis elsewhere*, making the patient too ill to produce union despite the absence of local tuberculous recrudescence. (One such case occurred at the Wingfield Hospital, the patient ultimately succumbing to phthisis a year or more after the operation—*Fig.* 375.)

FIG. 375.—Tuberculous knee after excision. Patient had serious phthisis, and despite accurate fit and immobilization union did not take place.

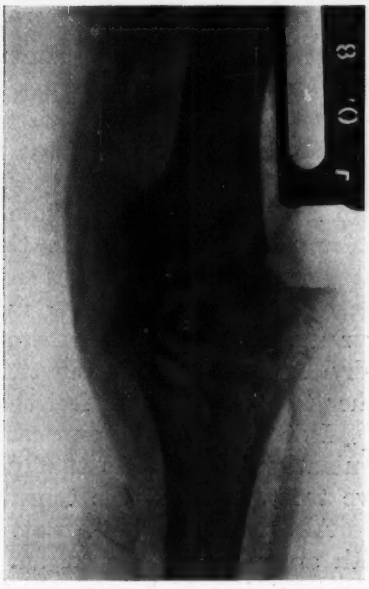


FIG. 376.—Result of old-fashioned excision on young child. Failure in fusion and disastrous damage to epiphysial discs. (*See Fig.* 377.)

FIG. 377.—Photograph of case seen in *Fig.* 376, showing the amount of shortening.

3. *Pyogenic infection from a sinus.* I think there is considerable danger from this.

4. *Ineffective immobilization*, allowing displacement between the end of the operation and the completion of the plaster, or harmful mobility afterwards.

5. Operation done on a very young patient is liable to fail either from: (*a*) lack of bony union because the ossific nuclei in the epiphyses are relatively small, (*b*) because secondary deformity develops from the unusual strains thrown on the young weak bone laid down on the metaphysial side of the growth disc, or (*c*) the classic error of the past—namely, interference with growth from too radical operation resulting in damage to one or both discs. I have a girl of 20 under my care; she was operated on elsewhere, and one of her legs is 7 in. short as a result of this catastrophe. (*Figs.* 376, 377.)

Success.—I asked my colleagues for their experiences as to the percentage of bony ankylosis after excision. A few have returned actual figures, notably Henderson, of the Mayo Clinic, who reports 194 excisions, with bony ankylosis in 171 cases (88 per cent). A distinguished Italian surgeon records 104 cases with 66·6 per cent of bony ankylosis; 26 other correspondents have returned figures (mostly estimated), and these average 87 per cent. My own series done by my colleagues and myself covers 26 cases done long enough to furnish end-results, with 88 per cent of sound bony ankylosis. There were three failures; one was the middle-aged woman ill with a superadded pyogenic infection already mentioned; the second was a middle-aged man with phthisis who died from that condition between one and two years afterwards (*Fig.* 375); the third, an adolescent, whose joint had been very extensively destroyed, has a sound fibrous but not bony ankylosis; he has been hard at work for more than three years, and there is no clinical or radiographic sign of tuberculosis. In the remaining 23 cases sound bony ankylosis resulted. Of our three failures one is a relative success, and in the other two cases I now feel that excision was contra-indicated.

I do not know of any case in which excision has led to tuberculous dissemination. Doubtless that danger is minimized by the previous conservative treatment and the tourniquet.

Altogether, I think that *excision of the knee* comes out of the inquiry with an enhanced reputation. Yet since it leads to the loss of movement in a joint in which movement is very valuable, I suggest that it should be confined strictly to those cases in which we know from the type of the disease, or from the age of the patient, or after a prolonged trial of conservative measures, that it is futile to hope for movement with sound safe healing. But although a soundly ankylosed knee compares poorly with a normal joint, it is far better than a thigh stump. Excision is a safe second string to our bow; for it provides a sure means of eradicating the local disease in all but the senile, the septic, or the advanced consumptive. In all the others we can say, "We'll try to save the joint, but, if that fails, we can and *will* save the limb."

Amputation.—To my question, "*What do you consider the indications in the age groups* 0–14, 15–50, *and* 50 *upwards, for amputation?*", Elmslie's answer is representative. "Amputation under 14 only when the case does very badly with conservative treatment. Young adults only when doing badly under conservative treatment and if the bone disease is too extensive for excision. Older people in any case unsuitable for excision."

Amputation is indicated only when either the patient or the limb has otherwise little prospect of recovery. That means that amputation is indicated *very rarely.* It should be confined to the patient who is very old or very ill, or to the knee which is very extensively diseased or heavily infected with pyogenic organisms. (*See Table IV.*)

If ordinary anæsthesia is contra-indicated we can rely on spinal anæsthesia, or avertin with the mild complemental respiratory anæsthesia necessary.

In children amputation should be left quite out of ordinary consideration; indeed, the number of our amputations in patients below middle age is a fair

indication of our skill in the happier measures. In the last twelve years I have done one such amputation, and I think I ought to have done a second, but Waldenström can say that in all his twenty years at the S. Gorin Hospital he has only had to do a single amputation!

Table IV.—Amputations for Tuberculosis of the Knee.
(*Wingfield Orthopædic Hospital.*)

	Age	Reason	Result
1	26	Very extensive pyogenic infection of fixed flexed knee	Good for a year or more, but subsequently developed lesions in spine and rib; still under treatment
2	39	Active phthisis	Good
3	60	Age*	Good, except for pain of phantom limb type
4	57	Age†	Good
5	36	Extensive pyogenic infection	Good
6	2	Active extending secondarily infected disease and general illness threatening life	Good
7	44	Active phthisis	Good

* Recrudescence of disease after 52 years.

† Tubercle not diagnosed till pathological report following synovectomy.

Sir Robert Jones has taught us that in a patient past middle age tuberculosis must be dealt with almost as radically as malignant disease. It is the real age, the senility of the patient in relation to the extent and activity of the local disease, that counts. There are very few indeed whom Osler would have found 'too old at 40' for excision, and some perhaps who are too young at 60 for amputation. I think Freiberg conveys a useful hint when he says: "We feel that amputations are probably not done often enough in patients beyond middle age." But I should not be fair to my collaborators if I did not express their unanimous revulsion against amputation. It is, indeed, a last resort.

Sinus Formation.—Just one word about sinuses. There is a vast difference between a tuberculous sinus and a sinus secondarily infected. A tuberculous sinus will, as a rule, close quickly if the general and local treatment is good.

It is a danger because it exposes the knee to the risk of pyogenic infection; and this catastrophe can only be avoided by *very* careful antiseptic dressings. The skin must not become sodden or eczematous: we wipe from the sinus spirally onwards with weak iodine or biniodide in spirit, and fix the dressing securely so that it cannot wander. Above all a tuberculous sinus should *never be probed.*

Arthroplasty.—I asked my colleagues: *Has arthroplasty any place in the after-treatment of tuberculosis of the knee?* There were 44 answers to this question, and 32 "Noes". Fairbank underlined his "No" four times, and Calvé said "Criminal". Very convincing, too, is a plain "No" from Putti, probably the greatest exponent of arthroplasty of the knee. It is also

interesting to note that 15 out of the 19 American orthopædic surgeons who answered the question said "No".

There remain 11 who give a qualified consent to the idea that an arthroplasty might possibly be warranted under exceptional circumstances—for example, as Willis Campbell points out, when first one knee has had to be fused and later the other has suffered in the same way. The particular circumstances of the case might warrant an arthroplasty of the first knee provided the time interval and radiographic appearances justified it. Incidentally I note that Willis Campbell reports 57 arthroplasties, but not one for tuberculosis.[2]

Bankart points out that by the time the operation is bacteriologically safe it is generally an unsound practical proposition on account of the condition of the muscles controlling the joint. Indeed, a sound ankylosis of the knee in good position is likely to be better than the sort of arthroplasty that will result at a very late stage, after a very chronic disease; and the ankylosis is certainly better for a working man or woman.

The fibrous ankylosis following conservative treatment is seldom permanently safe from recrudescence, and of course still less safe for arthroplasty. Time alone does not bring safety. I have a case in which tuberculous recrudescence occurred fifty-two years after the original attack.

I would sum up the matter by saying that in cases resulting *in fibrous ankylosis, arthroplasty is unsafe*, and *after bony fusion the parts are unsuitable.* And I unreservedly join those who hold that there is no place for arthroplasty in tuberculosis of the knee.

SUMMARY.

Pathology.—Tuberculosis of the knee is a dual disease—an outspoken lesion in the knee arising from another deep, unseen, and more dangerous lesion.

Cases can be classified into three groups by the topography of infection, and again into three groups by the age of the patient, and each group calls for a different line of treatment.

A.—Three Groups Distinguisable by Stereoscopic Radiograms:—

1. '*Extra-articular.*'—With purely extra-articular foci. The question of radical elimination of these foci by an extra-articular route is discussed, and Calvé's warning considered.

2. '*Focal-articular.*'—With bone foci communicating with the joint. Reasons are given for the decision that the joint should be fused, and the arthrodesis performed at a time chosen in view of the age, local, and general conditions.

3. '*Non-focal.*'—Without foci that can be seen in radiograms. In such cases in young children there is good hope of recovery with full movement after very long continued immobilization (*see Table I*).

B.—Three Groups Distinguishable by the Age of the Patient:—

1. Young children, 0–10, for whom prolonged immobilization is indicated, but neither diagnostic arthrotomy nor fusion.

2. The adolescents and adults, 15–50, for whom immobilization is preparatory to confirmation of diagnosis by arthrotomy, followed by fusion.

3. The elderly, from 50 onwards, for many of whom amputation is wiser than fusion.

Diagnosis.—*Provisional diagnosis*, coupled with immediate treatment, is the first step; after which for a time treatment and diagnosis run concurrently. In young children, indeed, a *clinical diagnosis*, carefully tested and reviewed, is sufficient.

Reasons are given for the conclusion that *diagnostic arthrotomy* is contra-indicated until the patient reaches an age when a positive diagnosis of tuberculosis will be quickly followed by fusion. The difficulties and risks of arthrotomy are discussed and a definition of its indications is suggested.

Treatment.—

General.—A combination of physical rest, metabolic stimulation by heliotherapy, well chosen and varied diet, and invigorating surroundings, serves to restore the vitality of the patient, and to raise it to a high level. This level should be maintained through the months or years of lymphatic disease and tuberculous bacillæmia. And the care must not be lessened or its period shortened because the knee has been fused.

Local.—There are only two safe end-results in tuberculosis of the knee—free movement and bony ankylosis.

The aim of local treatment, then, is the restoration of full movement; and, failing that, bony ankylosis. Immobilization is the paradoxical method of restoring movement.

Operative fusion is discussed, its rationale, its indications, its technical points, its contra-indications, and its failures. Figures are quoted. On the whole, it is highly successful; but should be avoided in those too young, too old, too ill, or obstinately septic.

A tuberculous sinus is a dangerous complication because its pyogenic infection is a disaster difficult to avoid.

Amputation has a restricted field as a life-saving measure for those disqualified for fusion by illness, age, or sepsis. Outside this field it is unanimously condemned.

Arthroplasty has no place in the treatment of tuberculosis of the knee or its results, for it is almost always either unsafe or impracticable.

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THREE CASES OF TORSION OF AN APPENDIX EPIPLOICA OF THE SIGMOID COLON.

By G. H. COLT,

SURGEON, ROYAL INFIRMARY, ABERDEEN.

A CASE of this condition recorded recently by C. E. Taylor[1] and a recent case of my own reminded me of two other specimens which I had sent to the Royal College of Surgeons Museum. Sir Arthur Keith has very kindly forwarded to me the catalogue descriptions of the cases, and Mr. Sewell has drawn the specimens for reproduction, which are shown natural size.

In Dr. Taylor's case the patient, a married woman of 50, had suffered for three weeks from acute intermittent epigastric pain, increasing in severity and worse after meals. She often vomited after a meal. The bowels were usually regular, but diarrhœa had been noticed. There had been no melæna and no blood had been passed by the bowel. The abdomen was slightly distended, especially on the left side, and was tender in the right epigastrium, where an indefinite mass was palpable. Opaque-meal examination had demonstrated a slight spasm of the pylorus and dilatation of the coils of the small intestine. There had been a similar attack of pain five years previously. At the operation all the other abdominal organs were found normal, and torsion of a sigmoid appendix epiploica, which measured 26 × 20 × 6 mm., was found. It was twisted about a very narrow stalk and was a dusky purple colour. There was no inflammation of the surrounding peritoneum. It showed dilated veins on the surface, the vessels were congested, and one contained a clot. There was no inflammatory reaction. The little tumour was removed and the patient made an uneventful recovery.

FIG. 378.

The three specimens in the Museum of the Royal College of Surgeons are as follows:—

I. (6109.1, R.C.S. Museum Catalogue).—The vermiform appendix and an appendix epiploica which were removed by operation from the same patient. The appendix epiploica, which was attached to the sigmoid colon, is swollen and of a dull purple colour from hæmorrhage due to torsion of its pedicle. Near the apex of the vermiform appendix a small appendix epiploica has also undergone torsion. (*Fig.* 378.)

From a married woman, age 51, who had suffered for five years from increasing

attacks of constipation, nausea, and occasional pain in the left iliac fossa. There had also been frequency of micturition dating from a confinement nine years previously. At the operation the abdominal and pelvic organs showed no pathological changes, except for those seen in the specimen. Radiological examination had shown no abnormality in the colon.

FIG. 379.

II. (6109.2, R.C.S. Museum Catalogue).—Two appendices epiploicæ adherent at their base, which were removed by operation from the sigmoid colon. One of them is partly of a deep purple colour due to hæmorrhage resulting from torsion. (*Fig.* 379.)

The patient, a woman, age 38, had undergone an operation four years previously for gangrenous appendicitis with abscess, which was drained. Since then there had been almost continuous pain in the left iliac fossa. During the last six months this had increased and was accompanied by attacks of constipation. There was no history of any acute initial attack. At the operation torsion of the appendix epiploica was found and two small bands of adhesions were present between the omentum and the lower part of the cæcum. The other abdominal organs were healthy.

III. (6109.3, R.C.S. Museum Catalogue).—An appendix epiploica with twisted pedicle, which was removed by operation from the middle of the anti-mesenteric border of the sigmoid colon. The pedicle consists of a narrow fibrous strand, not more than a millimetre in width at its distal attachment, and measuring ¾ in. in length. The appendix itself is firm, of a dull ochre-yellow colour, with a few small hæmorrhages in its substance. Its surface is free from inflammation or adhesions. (*Fig.* 380.)

FIG. 380.

The patient, a man, age 64, had been well until the present illness. Four hours after lifting a heavy table in an awkward manner he was seized with sudden pain in the right side of the abdomen, and felt sick and vomited. The vomiting was repeated ten hours later. The pain was mainly in the loin and continuous, and tenderness was present there. A small quantity of blood was brought away from the bowel by an enema. The urine was normal. There was a slight rise of temperature (99° F.). X-ray examination showed the absence of any calculus, but well-marked spondylitis of the lumbar vertebræ, and the fact that after operation there was a residual pain in the back and right loin for six days may have been evidence of the severity of the muscular strain. The diagnosis was subacute appendicitis. At the operation the vermiform appendix was retrocæcal in position and was not considered to be sufficiently inflamed to account for the symptoms. The twisted appendix epiploica was found as above mentioned and was removed. There was a marked terminal ileal kink. The descending colon was distended. The other abdominal organs were normal.

Diagnosis.—The condition would appear to be most common on the sigmoid, where appendices epiploicæ are most often seen. Though it might not be actually diagnosed, its presence might be strongly suspected if localized pain and tenderness with some functional disturbance of the bowel were present, and any gross lesion of the lumen, such as diverticulitis, were absent on radiological examination. In the four cases, the pain was intermittent and epigastric, with vomiting, worse after a meal, in one; in the left lower abdomen in two, with nausea in one of them; and on the right side in the fourth, with nausea and vomiting. The last patient, however, had strained his spine, which was already the site of osteo-arthritis.

More careful records in the future will no doubt help to elucidate the various points.

Treatment.—J. G. Knoflach[2] gives operation as the only treatment, and the degree of urgency appears from the severity of the case. He notes that care must be taken in respect of diverticulitis. In view of the discovery of loose bodies in the peritoneal cavity nature evidently sometimes takes the cure in hand.

REMARKS.

The condition is certainly more common than would appear from the fact that Johanssen[2] in 1927 collected 20 cases from the literature. Others have told me of cases. Knoflach[2] mentions the formation of loose bodies by spontaneous amputation and the formation of cords which may cause ileus. The origin of the bean-like structures lying free in the pouch of Douglas and discovered accidentally at operation must have puzzled many surgeons. I can recall three instances. Their discovery should indicate a careful examination of the large intestine. The cause of the torsion is obscure. We know of no records of its following directly on deep abdominal massage or of its being common in those who do exercises for their abdominal muscles. Neither do we know that *la danse de ventre*, which might be expected to twist anything twistable, does more than give an occasional twist to the morals of some of the audience. Knoflach mentions inflammation of other abdominal organs and obesity. In the case from which Specimen II was taken the symptoms dated from an attack of gangrenous appendicitis. He says that a very fatty appendix or one affected by a tumour has been described several times. The double Specimen I must be excessively rare, and supports this connection. He gives inability to stand upright as an important symptom. The boundary to peritonitis may be crossed. It is clearly possible that the condition may be a cause of peritonitis, especially when diverticulitis has accompanied it, and should be looked for specifically in the absence of any other cause.

REFERENCES.

[1] Taylor, C. E., *Brit. Med. Jour.*, 1931, i, 795.
[2] Knoflach, J. G., "Ueber intraabdominale Torsion des Netzes und der Appendices epiploicæ", *Deut. Zeits. f. Chir.*, 1930, ccxxv, 436.

SHORT NOTES OF RARE OR OBSCURE CASES

A LARGE MESENTERIC CYST IN AN INFANT SIX DAYS OLD.

By CECIL P. G. WAKELEY,
SURGEON TO KING'S COLLEGE HOSPITAL, LONDON.

Mesenteric cysts form a very definite group of cases, and have been recognized from the middle of the sixteenth century; up to the present

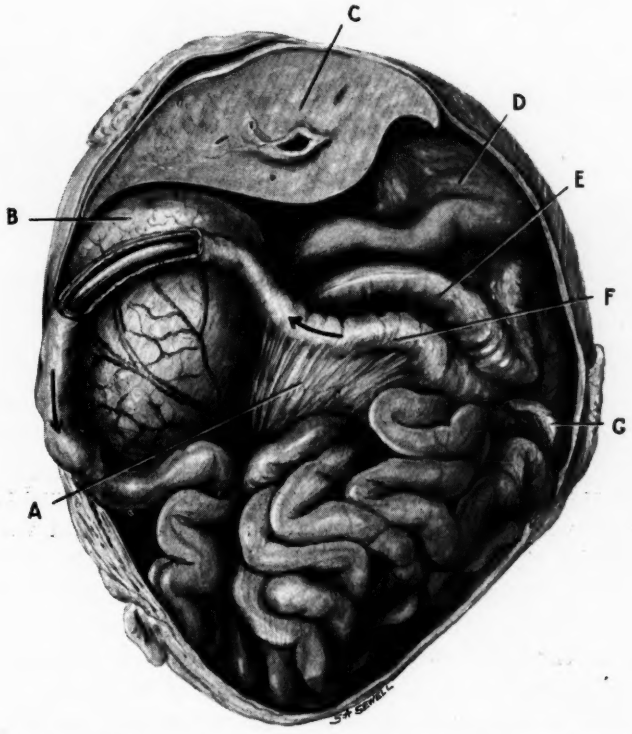

Fig. 381.—Abdominal and pelvic organs with part of the abdominal wall. The left half of the liver has been cut away. The mesenteric cyst can be seen lying in contact with the right lobe of the liver. A, Mesentery; B, Cyst; C, Liver; D, Stomach; E, Transverse colon; F, Jejunum; G, Appendix. (*R.C.S. Museum: Specimen No.* 6515.5.) (× $\frac{2}{3}$.)

time some three hundred cases have been reported in the literature, the majority having been discovered at operation.

Although they have been described in the fœtus and in adults, the commonest age at which they give rise to symptoms is round about puberty. The terminal ileum is the usual site for these cysts, although they have been described in any part of the mesentery.

The following case is deemed of interest because it occurred in a male infant which died on the sixth day after birth, from bronchopneumonia.

History.—The infant was the second child; the labour was normal, and although the cyst was a large one, it did not seem to cause any obstruction during delivery. The child was fed on the breast from the second to the sixth day, and passed its motions quite regularly. It was not treated by any doctor, and was brought up to hospital because its mother stated it could not breathe. On admission to hospital it was found to be dead.

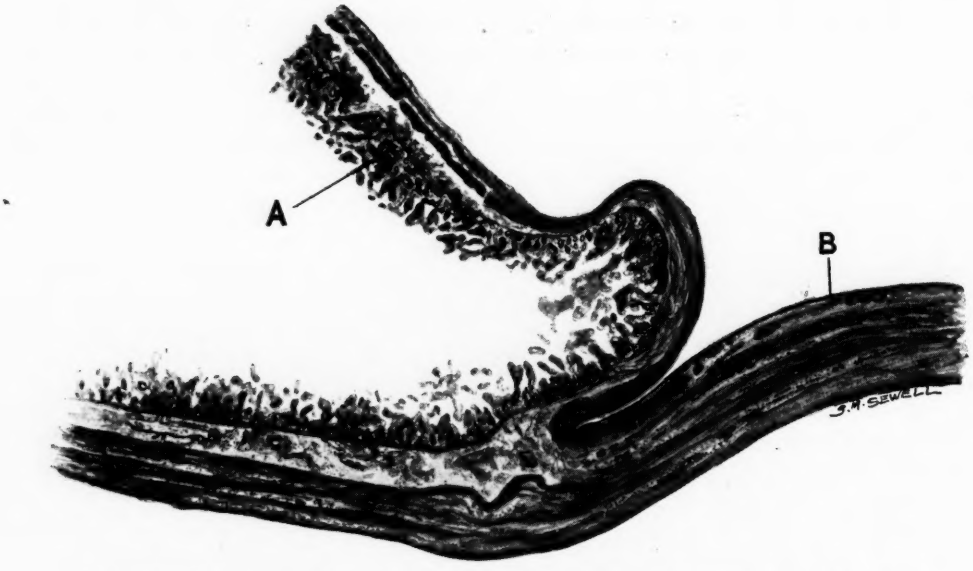

Fig. 382.—Microscopical drawing showing the junction of the cyst wall with the gut. A, Intestinal wall; B, Cyst wall. (× 10.)

Post-mortem.—At autopsy, the cause of death was found to be bronchopneumonia; this was not to be wondered at, as the child was taken some six miles along the streets of London by its aunt on the day of its birth. The abdomen was considerably distended, and on opening it, the distension was found to be caused by a large mesenteric cyst lying on the right side in the mesentery of the proximal jejunum. The cyst measured $2\frac{1}{4}$ in. in the chief antero-posterior diameter. It was connected with the concave border of the upper part of the jejunum and was enclosed within the layers of the mesentery (*Fig.* 381). The bowel was stretched over the upper surface of the cyst, but there was no communication between the two cavities. The cæcum and ascending colon were furnished with a distinct mesentery continuous with that of the ileum. Owing to the large size of the cyst, the cæcum and appendix were displaced towards the left iliac fossa. There was no block or atresia in any part of the alimentary canal.

Microscopical examination shows the cyst to be lined with a single layer of flattened oval or cubical cells, external to which is a layer of connective tissue, with scattered collections of lymphocytes. External to this layer is a broad layer of smooth muscle fibres, divided up in some places by strands of connective tissue; this layer is continuous with the circular muscle of the intestine, the two lying superimposed where the cyst and bowel are in contact (*Fig.* 382). External to the muscular layer is a narrow stratum of loose areolar tissue, continuous with the peritoneal covering of the bowel. The longitudinal muscle of the intestine is reflected on to the cyst wall for one or two millimetres; it then ceases abruptly, and is not elsewhere represented in the wall of the cyst.

The cyst contained a serous fluid in which was flocculent material consisting of granular matter and inflammatory and desquamated cells. It is apparently a lymphatic cyst of the submucosa of the intestine, which in enlarging has carried the circular muscle before it, while separating the longitudinal fibres.

The specimen is now in the Museum of the Royal College of Surgeons.

GASTRO-PHOTOGRAPHY CONTROLLED BY POST-MORTEM EXAMINATION.

By J. R. M. WHIGHAM,

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At a recent autopsy it was possible to compare a photograph of a carcinoma of the stomach taken during life with the findings present at death.

A man, R. H., age 67, was admitted to hospital on May 20. He had been ill with indigestion for about nine months, vomiting during the last month about half an hour after meals. There had been no hæmatemesis. On examination the patient was cachectic and a palpable mass was present in the epigastrium. The X-ray appearances following an opaque meal suggested the presence of carcinoma. On June 12 a gastro-photograph was taken, and the view of the anterior surface of the stomach showed the following appearances (*Fig.* 383). To the left there was a dark oval area surrounded by an irregular whitish margin, and to the right an area in which lighter shadows of varying intensity made up the field. The brightest of these were probably due to mucus.

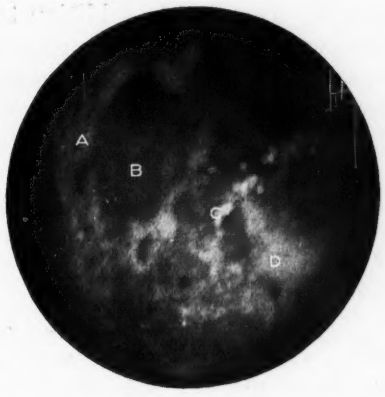

Fig. 383.—Gastro-photograph of carcinoma of stomach. A, Edge of ulcer; B, Base of ulcer; C, Mucus; D, Papillomatous area.

Nine days afterwards, on June 21, the patient died, and at the post-mortem examination the stomach was found to be the seat of a large carcinoma (*Fig.* 384), presenting features very much resembling those seen in the gastro-photograph. The anterior wall of the stomach was covered with papillomatous projections which in one place, towards the pylorus, had under-

FIG. 384.—Post-mortem appearances. A, Area of ulceration; B, Papillomatous growth; C, Cut edge of anterior surface of stomach near greater curvature. The upper part of this surface has been turned upwards. (× ½.)

gone ulceration. In addition to the image of the growth, which is sufficiently striking, some accuracy of localization was also obtained, two considerations which should give encouragement for the future in this method of gastric investigation.

I am much indebted to Baron Von Veitschberger for assistance with the photography in this case.

REVIEWS AND NOTICES OF BOOKS.

A Textbook of Surgery. By JOHN HOMANS, M.D., Assistant Professor of Surgery. Compiled from Lectures and other writings of various members of the Surgical Department of the Harvard Medical School. Royal 8vo. Pp. 1195 + xii, with 513 illustrations. 1931. London: Ballière, Tindall & Cox. 40s. net.

THE most natural question to ask on meeting a new text-book of surgery is whether it can justify its publication as an addition to the large number already available. It may be said at once that this volume, compiled after eight years of strenuous effort by Dr. Homans, from the lectures and writings of a score of teachers in the Harvard Medical School, possesses certain features which amply justify its existence. Besides, it is a pleasant book to handle and to read, being printed in clear type on specially made paper.

At the present time a laudable and increasing interest is being shown in the history of science, and there are many who would welcome the introduction of lectures on the history of medicine into the course of study for a qualifying degree. A better plan still is to present each subject in its correct historical setting—and this is best done at the bedside or in the demonstration room—showing how the present position has been arrived at in each field. All will welcome the attempt made in this book to carry such a plan into practice, for each chapter begins with a short historical sketch which is not only of interest, but of great value to the student. The anatomy and physiology of each system is briefly but adequately described, and upon this foundation the pathological and clinical picture is built up. It will be seen that the work has been well conceived; and its real object—to record the teaching of surgery at the present day in the Harvard School—is in itself sufficient to recommend its careful study.

In order to limit the size of the book to one volume the author has decided to concentrate upon the practice of surgery, and to exclude the lengthy and often redundant chapters on pathology which the older books contain. In this we believe he has acted wisely, for now that the student has many works on pathology to refer to, he will be less than ever inclined to pay any attention to the pathological section in the surgery book, which is therefore better omitted. The present work contains just about as much pathology as is indispensable.

Another feature which makes it particularly attractive is a bibliographical index, which, though it cannot be exhaustive, gives references to most of the important surgical literature, and is certain to supply not only information but also a stimulus to further study. It is essentially a students' text-book and not a book of reference, nor does its size permit of the inclusion of theoretical matter dealing with the many unsolved problems of surgery. It will therefore not be of real help to those studying for the higher surgical degrees and diplomas.

Some sections are particularly good, especially those on the nervous system and the chest; the greater part of the book is of the standard indicated above; and a few chapters are in comparison surprisingly poor. For instance, the descriptions of all the chronic infections of bone, cystic disease of bone, and the diseases of bone which are apparently of metabolic origin, all require revision. The accounts of most of the tumours, more especially of the salivary gland tumours, melanoma, hypernephroma, and tumours of the testis, are very sketchy and incomplete. The lack of discussion of subjects only partially understood is brought out when a giant-cell tumour of bone is described as an inflammatory condition, without giving the student any good evidence against its being a neoplasm. The genito-urinary system

as a whole gets less than its fair share of space, and diseases of the testis are practically omitted altogether. Such defects are so obvious that they will doubtless be attended to in future editions.

The book is illustrated by plentiful drawings, most of which give a clear picture of the subject in the text; but it is evidently difficult, if not impossible, to make a good drawing of a skiagram, for most of the reproductions of X-ray pictures would be better omitted unless reproduced as photographs. It is natural to suppose that the book is intended primarily for Harvard men, and for medical students on the other side of the Atlantic. In spite of its many good qualities, it seems unlikely to replace the books to which students on this side have become accustomed.

On Faith and Science in Surgery. By Sir JOHN BLAND-SUTTON, Bart., Vice-President and Consulting Surgeon to the Middlesex Hospital. Post 8vo. Pp. 109 + xii. Illustrated. 1930. London: Willam Heinemann (Medical Books) Ltd. 7s. 6d. net.

WE all rejoice to see how gently time has dealt with Sir John Bland-Sutton; in this little volume he has published ten addresses delivered during the last five years in various cities of England, Scotland, Canada, and America. There is no sign of loss of vigour in his writing, nor has custom staled his infinite variety. Like all his writings, this book is charming: it should be read in a comfortable chair after a hard day's work; whether Sir John is talking of ligatures, of pearls and gall-stones, of cod-liver oil, of Jonah and the whale, or of the parasitic origin of man, the reader is held enthralled—"and still the wonder grew, that one small head could carry all he knew."

One of the joys peculiar to reading books by Sir John is the aptness of his quotations; we all know how fond he is of the Bible and Shakespeare; in the chapter on "Food and Physic" he quotes a very neat and appropriate couplet by Kipling:—

> "Anything green that grew out of the mould
> Was an excellent herb to our fathers of old."

As in this and the preceding chapter, on "Faith in Drugs", he takes the opportunity of smiling at the prescriptions of the older physicians, we wonder he could resist the temptation of placing at the head of these—"I perceive that in all things ye are too superstitious."

The illustrations are excellent and add greatly to the pleasure of reading this book. We heartily commend it to our readers.

Modern Surgery. By CHALMERS J. DACOSTA, M.D., LL.D., F.A.C.S., Samuel D. Gross Professor of Surgery, Jefferson Medical College; assisted by BENJAMIN LIPSHUTZ, M.D., F.A.C.S., Surgeon to the Mt. Sinai Hospital, Associate in Neuro-anatomy, Jefferson Medical College. Tenth edition, revised and reset. Royal 8vo. Pp. 1404, with 1050 illustrations, some in colours. London and Philadelphia: W. B. Saunders Co. 45s. net.

THIS may be described as a wonderful book, and the epithet may be applied to several of its features. In the first place, it is no mean achievement to have written a book of 1400 pages and to have carried it through several editions without assistance, even if we allow that in the preparation of the last two or three editions the author is much indebted to Dr. Lipshutz for the addition of new matter and very careful revision of former chapters; but it is even more wonderful when one realizes that it is nearly forty years since the book first appeared, and that, apart from having passed through so many editions, it has also been reprinted on innumerable occasions. The author's endeavour has apparently been to include everything possible, and not to exclude as much as he possibly can. Thus there is a long chapter devoted to the resuscitation of the asphyxiated and drowning, and a most fascinating account of the history of blood transfusion. Not only may it be regarded as a text-book of descriptive surgery, but all the operations in common use are described in detail, as are many which are more rarely performed. It is a remarkable compendium of surgical knowledge of which any surgeon, American or British, would be proud to be the author. Dr. DaCosta's energy and persisting enthusiasm

is all the more remarkable as he has just published a volume of selections from his papers and speeches, which range from "The Personal Side of Pepys" to "Medical Paris during the Reign of Louis Phillippe". His quotation on the fly-leaf of a charming verse from W. W. Story's *Contemporary Criticism* would at once disarm any reviewer who had critical intentions, but nevertheless, the present writer, claiming to be no less a lover of Dickens than Dr. DaCosta himself, must dissent from the misquotation of a paragraph most aptly introduced into the preface of this edition.

Operative Surgery: General and Special Considerations. By Dr. MARTIN KIRSCHNER (Tübingen), authorized translation by I. S. RAVDIN, B.S., M.D. (Philadelphia). Super royal 8vo. Pp. 666 + xii, with 746 illustrations, mostly coloured. 1931. London: J. B. Lippincott Co. 50s. net.

THE drawings in this book are most artistic, and nearly all of them are coloured. It remains questionable, however, whether the illustrations are not overdone. Many of them are quite unnecessary, for methods and instruments are illustrated which the author confesses are of little value or out of date. Apart from this, it is a first-class book. Essentially one of technique, it is full of sound practical wisdom. The house surgeon will pick up from it many useful tips. Particularly well written is the chapter on the control of pain. All the more recent anæsthetics and the methods for their administration are described, and a very complete account of conduction anæsthesia is added. The chapters on hæmorrhage, shock, and transfusion are excellent. Clear indications are given of what constitutes a 'bad-risk' patient, and full instructions how these risks may be obviated by careful pre-operative investigation. The book is well translated.

The Management of Abdominal Operations. By RODNEY H. MAINGOT, F.R.C.S., Surgeon, Royal Waterloo Hospital, London. Crown 8vo. Pp. 312 + xii. 1931. London: H. K. Lewis & Co. Ltd. 7s. 6d. net.

THE author of this book has undoubtedly filled a gap in surgical literature. It would have been better, in a work so full of views on which much criticism could be made, had he indicated the appropriate origin of such opinions under the proper chapter heading, instead of lumping his numerous co-editors together in the Preface. We should also have thought better of the book if the author had omitted a description of operations (many of them in our opinion inaccurate) and had concentrated on pre- and post-operative treatment.

Beginning with 'anæsthesia', he discusses in succeeding chapters (there are sixty-five) every possible kind of complication, and, in addition, gives an excellent account of pre- and post-operative treatment. Many pages are left blank for notes to be added by the reader.

The book is good in every way. It is a veritable 'gold mine' for a house surgeon or a senior student. It is a very useful reference book for an operating surgeon, and an excellent guide for the general practitioner and for nurses. The author has managed, by avoiding 'padding', to compress an enormous amount of information into singularly little space. He writes well and has chosen his co-editors with much judgement.

Abdominal Pain. By JOHN MORLEY, Ch.M., F.R.C.S., Assistant Surgeon, Manchester Royal Infirmary, etc. With an Introduction by J. S. B. STOPFORD, M.D., F.R.S., Professor of Anatomy, University of Manchester. Medium 8vo. Pp. 191 + xvi, with 22 illustrations. 1931. Edinburgh: E. & S. Livingstone. 10s. 6d. net.

THE author's clinical investigations and papers upon the nature and significance of pain are well known. In this volume he reviews theories of the causation of abdominal pain which from time to time have held the field, and in particular closely examines the physiological basis of Mackenzie's theory, which was founded on the hypothesis of James Ross. After reviewing the contributions of Lennander, Hurst, Head, and others, the author then enunciates his own theory of abdominal pain. The

remainder of the book is taken up with observations upon the variations of pain in diseases and injuries of the different abdominal viscera and an endeavour to show that the author's hypothesis of the nature of abdominal pain is capable of closer correlation with clinical experience than any theory which has preceded it.

Chirurgie de l'Ulcère gastrique et duodénal (Indications. Résultats). By N. HORTOLMEI, Professeur de Clinique chirurgicale; and VL. BUTUREANU, Maître de Conférences, Faculté de Médecine de Jassy. Medium 8vo. Pp. 408, with 75 illustrations. 1931. Paris: Masson et Cie. Fr. 45.

THIS book will interest anyone engaged in gastric surgery. It contains an account of the various methods of surgical relief which have been devised and put into practice, with a critical review of the results as revealed by the literature of the subject, which has been very thoroughly searched. No one can read a book of this description without realizing that the final word on the surgery of the stomach has yet to be said. There are methods advocated by enthusiasts which have failed to gain recognition, such as Latarjet's denervation procedure, or are yet under trial, such as Babcock's cholecysto-gastrostomy recently revived by Braithwaite. Yet in the end the present-day problem resolves itself into that of deciding whether extensive gastroduodenal resections or some indirect method is preferable for gastric or duodenal ulcers. The natural dislike of the modern surgeon for resections for small pathological lesions is understandable and praiseworthy. But with our present ignorance of the etiology of gastric ulcer, it is at least a logical plan to ensure that conditions are so changed that gastric ulcer formation is almost impossible, even at the cost of the loss of a considerable part of the stomach. It is interesting, too, to observe how gastroduodenal resection is gradually making its way as a remedy for duodenal ulcer in France as well as in Central Europe. The authors of this book are frank advocates of large gastroduodenal resections, which they recommend should be carried out by the Reichel Pólya method, after which they declare they have never seen any serious trouble even after years have elapsed. They also strongly recommend some form of local as against general anæsthesia, finding spinal anæsthesia with novocain a satisfactory method. The drawback of its limited duration is removed by continuing with splanchnic and parietal infiltration when the operation lasts more than one to one and a half hours. They also follow the custom of Finsterer, unusual in this country, of draining the region of the parietal stump in every gastric resection performed by them. There is a very interesting chapter on the physiology of gastric resections, and the discussion of the many problems of gastric surgery is always well presented, with an appreciation of the essential problems.

Clinical Observations on the Surgical Pathology of Bone. By DAVID M. GREIG, M.B., C.M., F.R.C.S.E., F.R.S.E., Conservator of the Museum of the Royal College of Surgeons of Edinburgh. Large 4to. Pp. 248 + xii, with 224 illustrations. 1931. Edinburgh: Oliver & Boyd. 30s. net.

THE author of this most interesting monograph is one of those who, from prolonged clinical experience combined with intensive study of pathology, have earned the right to generalize and formulate principles regarding bone disease. This treatise is attractive reading, being the work of an enthusiast as well as a keen observer, set out in admirable English. A motif runs through the book—it is that hyperæmia means bone absorption, excess of calcium and relative anæmia bone deposition or sclerosis. The work of Leriche and Policard is illustrated from all standpoints, and the researches of Dale and Lewis on histamine and acetylcholine in relation to vascular dilatation are pushed to the limits of their applicability. The illustrations are of a very high standard, and their value is greatly enhanced by the clinical histories which are supplied in the text.

Certain criticisms are called for. In some chapters the narrative proceeds from one subject to another without any headings to relieve the monotony of the text, the page headings being the only indication of the change. Very dogmatic views are expressed on controversial subjects without the furnishing of data in support

of them. One would have expected some photomicrographs or drawings to illustrate the conditions which are so minutely and confidently described. These criticisms are made because the book is so good that we could have wished it to be still more comprehensive. It should be read by all who interest themselves in surgery or pathology.

Surgical Pathology of the Skin, Fascia, Muscles, Tendons, Blood, and Lymph Vessels. By ARTHUR E. HERTZLER, M.D., Professor of Surgery, University of Kansas. Hertzler's Monographs on Surgical Pathology. Royal 8vo. Pp. 301 + xvi, with 260 illustrations. 1931. London: J. B. Lippincott Co. 21s. net.

THIS book is one of an ambitious series of nine monographs on surgical pathology, one of which, on the diseases of bone, has already appeared, the others being in process of preparation. The present volume is on conventional lines, the various affections being separately discussed, exampled by an appropriate case, and accompanied by excellent illustrations and microphotographs. The space assigned to each condition has been carefully assessed, with the possible exceptions of Volkmann's ischæmia and Dupuytren's contracture, which, surely, in a work of this size, deserve more than the half page allotted to them. Omissions are few, the chief being an entire absence of any mention of idiopathic elephantiasis, that most curious of lymphatic diseases. The author's opinions on the etiology of the massive thickening of the deep fascia which is the invariable accompaniment of this condition would be of considerable interest.

Most of the theories advanced will be acceptable to the majority of British pathologists. The vexed question of the origin of the sebaceous cyst is discussed at considerable length, and Professor Hertzler, in pointing out that the cyst, when very small, is unattached to the skin, states his own belief that it arises from an abortive sacculation of the epidermis which has failed to develop into a sebaceous gland. With this, as with his somewhat arbitrary classification of the melanomas, one may be inclined to disagree, but the author's mature experience, and his masterly presentation of cases and researches, must inevitably command respect. The style is concise and pithy, making excellent reading, and altogether the book is worthy to rank with the best type of contemporary American writing.

Medizinische Praxis Sammlung für ärztliche Fortbildung. Edited by L. R. GROTE, A. FROMME, K. WARNEKROS. Vol. VII. Grundzüge der Neurochirurgie, by Prof. Dr. Med. WALTER LEHMANN (Frankfurt a. M.) Medium 8vo. Pp. 197 + xii, with 23 illustrations. 1930. Dresden and Leipzig: Theodor Steinkopff. Paper covers, 13.50; bound, RM. 15.

THIS book presents briefly, but most ably, an excellent summary of contemporary German thought on the pathology, diagnosis, and treatment of those nervous lesions which come within the scope of the surgeon. The author has taken into consideration also the views of the leading authorities in other countries. The sections are short, but are packed with information, and a very high standard is maintained throughout. The chapters on brain tumours, on spinal lesions, on the surgery of pain, and of the sympathetic nervous system are useful résumés of the work which neurological surgeons have to do. It is a book which can be dipped into with interest by everybody, and is particularly valuable to us in this country because it contains the views of German workers with full references to their original papers.

La Sacro-coxalgie et son Traitement. By PIERRE INGELSANS. Pp. 142, with 6 plates, Paris: Masson et Cie. Fr. 30.

A MONOGRAPH on tuberculous disease of the sacro-iliac joint, based on thirty-eight cases which are recorded in full. The author finds that diagnosis both by clinical methods and by radiographs is difficult. Most of the classical signs, such as that of Erichsen by compression of the pelvis, fail, and X-ray changes are often late. On the other hand, sciatica and localized pain and swelling over the joint posteriorly are usual. Abscess was present in twenty out of thirty-eight cases. The author advocates a fixation operation, using a graft from the posterior part of the ilium.

Injuries and Sport. A General Guide to the Practitioner. By C. B. HEALD, C.B.E., M.A., M.D. (Cantab.), M.R.C.P. (Lond.), Physician, with charge of Electrotherapeutic Department, Royal Free Hospital, etc. Demy 8vo. Pp. 543 + xxiv, with 380 illustrations. 1931. London: Humphrey Milford. Oxford University Press. 25s. net.

THE author has attempted a difficult task; he has endeavoured to give an account of the common injuries arising in sport of all sorts and to deal with their causation, pathology, and treatment, including under the last-named splinting, surgical intervention, and physical treatment. Dr. Heald's own work is concerned with the last named, and perhaps he would have been better advised to confine himself to his own specialty. His excursions into pathology and surgery are often open to criticism, his methods of splinting, as judged by the illustrations, are often crude, and the appliances illustrated inaccurate. For example, on p. 412 is an illustration of a "walking calliper for convalescent treatment of a fractured tibia". The appliance is not a caliper but a knee-cage with outside steel continued to the boot; it takes no bearing either on the head of the tibia or tuber ischii, and the side steel is on the wrong side if it is intended to act as a protection for non-union of the bone with a tendency to outward convexity. In fact, everything is wrong—including the spelling.

Dr. Heald quite rightly states that the diagnosis of an injury is only complete and efficient when it presents to the mind a true picture of the pathological condition of the injured part, but it is to be feared that this ideal is not carried out in the sections on special injuries. For example, he apparently still believes in the fable of the ruptured plantaris; Schlatter's disease is still to him a separation of the epiphysis of the tubercle of the tibia, and "progress must be watched by periodic X rays"—presumably to see the epiphysis reunite. Again, the importance of getting an accurate history of the exact mechanism of the production of an injury is not followed up in detail. The mechanism of production of dislocations of the semilunar bone and of fracture of the scaphoid in the wrist are not mentioned, and the occurrence of the latter as a handing-off injury at football is omitted. No mention is made of the frequent occurrence of strain of the internal lateral ligament as a skiing injury, and there are other examples of the omission of special games injuries of this sort, such as basal fracture of the terminal phalanx of the finger in wicket-keeping.

The book is well written and well illustrated. It gains interest by showing many well-known specialists in games in action photographs, and by illustrations of sports accidents. It will help the practitioner in the general diagnosis of injuries, but it is to be feared that the accounts of general mechanical and surgical treatment are not such as will commend it to the student or surgeon, and the methods of physical treatment described are really those of the specialist.

Gonococcal Infection in the Male. By A. L. WOOLBARST, M.D., Urologist and Director of Urological Clinics, Beth Israel Hospital, etc. Second edition, completely revised and enlarged. Medium 8vo. Pp. 297, with 140 illustrations, including 7 coloured plates. 1930. London: Henry Kimpton. 25s. net.

THIS monograph gives an excellent account of gonorrhœa and its complications in the male; it is clearly printed, very readable, and the illustrations are numerous, good, and help to elucidate the text.

We note with interest the author's personal conviction, set out in the preface to this edition, "that gonorrhœa must be considered a constitutional disease which can be cured only by the inherent reparative forces of the individual, acting through the blood-stream". This conviction is supported by a further statement of his that "the usual course of acute gonorrhœa is from eight to twelve weeks": and this in spite of his many years' experience as a urologist and of the almost innumerable methods of treatment that have been tried during the last thirty years. It really seems that the treatment of this disease has advanced little, if at all, since the days of Sir Henry Thompson. Indeed, the author seems to have abandoned the irrigation method of Janet and to have returned to the use of the syringe.

He considers that vasotomy (Belfield's operation) is the most valuable modern

advance in the management of gonococcal arthritis, and that this is the one possible way of reaching the vesiculæ seminales with salts of silver or other injections; judging, however, from his illustration of the anatomy of these structures, it would seem probable that the fluid might run straight into the prostatic urethra without filling the vesiculæ.

The chapter on sexual neuroses following gonorrhœa is interesting; the author appears to consider that they are due to local lesions in the prostatic urethra combined with a 'neurasthenic soil'; he advocates local treatment by diathermy, etc., through a urethroscope.

The author is to be congratulated on having brought this second edition of his book so fully up to date.

BOOK NOTICES.

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.*]

Modern Proctology. By MARION C. PRUITT, M.D., F.R.C.S.E., F.A.C.S., Associate in Surgery, Emory University School of Medicine, etc. Super royal 8vo. Pp. 404, with 233 illustrations. 1931. London: Henry Kimpton. 36s. net.

Minor Surgery. By LIONEL R. FIFIELD, Late Surgical First Assistant and Registrar, London Hospital. Second edition, revised by R. J. McNEILL LOVE, M.S. (Lond.), F.R.C.S., Surgeon, the Royal Northern Hospital, etc. Crown 8vo. Pp. 440 + viii, with 281 illustrations. 1931. London. H. K. Lewis & Co. Ltd. 12s. 6d. net.

Emergency Surgery. By HAMILTON BAILEY, F.R.C.S., Surgeon, Royal Northern Hospital. Vol. II. Thorax, Spine, Head, Neck, Extremities, etc. Large 8vo. Pp. 415 + xviii, with 430 illustrations, some in colour. 1931. Bristol: John Wright & Sons Ltd. 25s. net.

Die Schliemhaut des Verdauungskanals im Röntgenbild. By HENRI CHAOUL and ALBERT ADAM, with a Foreword by FERDINAND SAUERBRUCH. Imperial 8vo. Pp. 229 + viii, with 219 illustrations. 1931. Berlin and Vienna: Urban & Schwarzenberg. Paper covers, RM. 22.50; bound, RM. 25.

Chirurgische und konservative Kosmetic des Gesichtes. Edited by Dr. LEANDER POHL (Vienna). Large 8vo. Pp. 383 + viii, with 445 illustrations and 3 coloured plates. 1931. Berlin and Vienna: Urban & Schwarzenberg. Paper covers, RM. 25; bound, RM. 28.

Surgical Pathology of the Genito-urinary Organs. By ARTHUR E. HERTZLER, M.D., Professor of Surgery, University of Kansas. Hertzler's Monographs on Surgical Pathology. Royal 8vo. Pp. 286 + xviii, with 222 illustrations. 1931. London: J. B. Lippincott Co. 21s. net.

Atlas de Radiographie osseuse, I. Squelette normal. By G. HARET, A. DARIAUX, Electro-radiologistes des Hôpitaux de Paris; and JEAN QUÉNU, Professeur agrégé à la Faculté de Médecine, Chirurgien des Hôpitaux de Paris. With the collaboration of H. P. CHATELLIER, Oto-rhino-laryngologiste des Hôpitaux. Second edition, revised and enlarged. Preface by PIERRE DUVAL. Large 4to. Pp. 186, with 149 illustrations. 1932. Paris: Masson et Cie. Fr. 200.

Atlas de Radiographie osseuse. II. Pathologie. In two volumes. Vol. I. Lésions traumatiques. By G. HARET and A. DARIAUX, Electro-radiologistes des Hôpitaux de Paris; and JEAN QUÉNU, Professeur agrégé à la Faculté de Médecine, Chirurgien des Hôpitaux de Paris. Vol. II. Lésions non traumatiques. By ETIENNE SORREL, Chirurgien de l'Hôpital Trousseau; and Mme. Y. SORREL-DEJERINE, Ancien Interne des Hôpitaux. Large 4to. Pp. 344, with 897 illustrations. 1931. Paris: Masson et Cie. In two volumes, Fr. 310; in one volume, Fr. 280.

Bendien's Diagnostic Methods for Cancer and Principles of Treatment. By A. A. MILLER, M.D. With an Introduction by Dr. S. G. T. BENDIEN. Crown 8vo. Pp. 80, with 9 illustrations. 1931. London: H. K. Lewis & Co. Ltd. 3s. 6d. net.

Guy's Hospital Reports. Edited by ARTHUR F. HURST, M.D. Vol. LXXXI (Vol. XI, Fourth Series). No. 3. July, 1931. Royal 8vo. Pp. 253–378. Illustrated. 1931. London: The Lancet Ltd. Single numbers, 12s. 6d. net; annual subscription, £2 2s. net.

Tumours of the Breast: their Pathology, Symptoms, Diagnosis and Treatment. By Sir G. LENTHAL CHEATLE, K.C.B., C.V.O., F.R.C.S., Consulting Surgeon and Emeritus Lecturer on Surgery, King's College Hospital, London; and MAX CUTLER, B.Sc., M.D., Director of Tumor Clinic, Michael Reese Hospital, Chicago. Large 8vo. Pp. 596 + viii, with 468 illustrations and 18 coloured plates. 1931. London: Edward Arnold & Co. 50s. net.

Division palatine: Anatomie—Chirurgie phonétique. By VICTOR VEAU, Chirurgien de l'Hôpital des Enfants assistés, with the collaboration of Mme. S. BOREL. Large 8vo. Pp. 568 + viii, with 786 illustrations. 1931. Paris: Masson et Cie. Fr. 140.

Traitement du Bec-de-lièvre unilatéral (Procédé du Dr. Veau). By PAUL PLÉSSIER, Ancien Interne des Hôpitaux de Paris. Large 8vo. Pp. 148 + iv, with 106 illustrations and 16 plates. 1931. Paris: Masson et Cie. Fr. 30.

Thomson and Miles' Manual of Surgery. By ALEXANDER MILES, M.D., LL.D., F.R.C.S.E., Consulting Surgeon, Royal Infirmary, Edinburgh; and D. P. D. WILKIE, M.D., F.R.C.S.E., Professor of Surgery, University of Edinburgh. Eighth edition. Crown 8vo. Vol. II. Extremities, Head and Neck. Pp. 685 + viii, with 303 illustrations. Vol. III. Thorax and Abdomen. Pp. 578 + xii, with 177 illustrations. 1931. London: Humphrey Milford. 12s. 6d. net each.

The Laboratory in Surgical Practice. By C. E. DODDS, M.V.O., M.D., Courtauld Professor of Biochemistry in the University of London, etc.; and LIONEL E. H. WHITBY, C.V.O., M.D. (Camb.), M.R.C.P. (Lond.), D.P.H., Bacteriologist to the Middlesex Hospital, Bland-Sutton Institute of Pathology, etc. Demy 8vo. Pp. 187 + x. Illustrated. 1931. London: Constable & Co. 8s. 6d. net.

La Pratique chirurgicale illustrée. By VICTOR PAUCHET. Fasc. XVII. Super royal 8vo. Pp. 268 + vi, with 186 illustrations by S. Dupret. 1932. Paris: Doin et Cie. Fr. 65.

Lehrbuch der Röntgendiagnostik. By H. R. SCHINZ, W. BAENSCH, and E. FRIEDL, with the collaboration of M. HOLZMANN, A. HOTZ, O. JÜNGLING, E. LIEBMANN, E. LOOSER, and K. ULRICH. Third edition. Two volumes. Imperial 8vo. Pp. 1623 + xxviii, with 2714 illustrations and 5 photographic plates. 1932. Leipzig: Georg Thieme. Paper covers, M. 214; bound, M. 220.

Indikation und Technik des künstlichen Pneumothorax. By Dr. HEINRICH MAYRHOFER (Vienna). Large 8vo. Pp. 35, with 33 illustrations. 1932. Vienna: Julius Springer.

Chirurgische Indikationen für Ärzte und Studierende. By Prof. Dr. KARL RESCHKE (Griefswald). Vol. I. Super royal 8vo. Pp. 357 + viii. 1932. Berlin: F. C. W. Vogel. Paper covers, RM. 22; bound, RM. 24.

Fractures of the Jaws. By ROBERT H. IVY, M.D., D.D.S., F.A.C.S., University of Pennsylvania; and LAWRENCE CURTIS, A.B., M.D., D.D.S., University of Pennsylvania. Medium 8vo. Pp. 180 + viii, with 177 illustrations. 1932. London: Henry Kimpton. 21s. net.

Matas Birthday Volume. A Collection of Surgical Essays written in Honor of Rudolph Matas, New Orleans. Super royal 8vo. Pp. 396 + xiv. 1931. New York: Paul B. Hoeber, M.C. $10.00.

Annals of Roentgenology. Edited by JAMES T. CASE (Chicago). Vol. XIII. Gynecological Roentenology, by JULIUS JARCHO, M.D., F.A.C.S. (New York). Large 8vo. Pp. 571 + xxvi, with 273 illustrations and 5 coloured plates. 1931. New York: Paul B. Hoeber, Inc. $20.00.

Wayfaring in a Splint. By OTTILIE WALLACE. Pott 8vo. Pp. 52 + x. Illustrated. 1931. London: Humphrey Milford. 2s. 6d. net.

Specific Changes in the Blood Serum. A Contribution to the Serological Diagnosis of Cancer and Tuberculosis. By S. G. T. BENDIEN, Serological Laboratory, Zeist, Holland. Translated by A. PINEY, M.D., Director of the Pathological Department, the Cancer Hospital, London. Royal 8vo. Pp. 95 + xii, with 64 illustrations and 5 spectra in the text and on 8 plates. 1931. London: Wm. Heinemann (Medical Books) Ltd. 10s. 6d. net.

Surgical Pathology of Prostatic Obstructions. By ALEXANDER RANDALL, M.A., M.D., Professor of Urology, University of Pennyslvania. Large 8vo. Pp. 266 + xiii, with 78 plates. 1931. London: Baillière, Tindall & Cox. 37s. 6d. net.